Nova Scotia
Department of
Mines and Energy

THE DEVELOPMENT POTENTIAL FOR NOVA SCOTIA'S OFFSHORE AGGREGATE AND PLACER RESOURCES

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by
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PLACER GOLD

INTRODUCTION

All of the early discoveries of gold in the Province were of detrital gold in unconsolidated materials. Based on the experience of the gold placer discoveries in Australia and California, the colonial government under Joseph Howe expected that Nova Scotia's gold resources would be of the placer-type and set out to regulate the industry on that basis. Mining lots were set at 50 x 30 feet in areas where gold was found; this allowed all eager Nova Scotians to partake in the lottery of gold mining.

Contrary to expectations most of the gold found was in lode-form. Extracting gold required effort, expertise and capital. The size of mining lots were increased to 250 x 150 feet on land, and set at 33 x 30 feet at the Ovens beach placer deposit.

Prospecting continued for deposits of detrital gold, but the amount of gold found was disappointing. Eventually, interest in looking for mineable placer gold deposits waned. Some geologists believed that

sizeable placer deposits should exist while others said that glaciation had destroyed the placer concentrations in pre-glacial gravels, and that no economic concentrations of alluvial gold could be expected. No significant placer deposits were ever found although limited mining was done at the Ovens and Middle River. Detrital gold became primarily an exploration tool to locate lode gold deposits whereby glacially-derived auriferous detritus was traced back to their sources.

Detrital gold is prolific in the Province due to glaciation of a auriferous host rock. Subsequent sections discuss why offshore Nova Scotia is once again being considered for its placer gold potential.

GOLD OCCURRENCES OF NOVA SCOTIA

Nova Scotia, despite its small land area, contains a great diversity of rock-types which represent tectonic events spanning 900 million years. Precious metals, most notably gold, occur in a wide variety of rocks and unconsolidated materials throughout the entire stratigraphic column. The Province contains about 190 gold occurrences (Ponsford and Lyttle, 1984), (Fig. 1) that can be categorized as being either lode, paleoplacer or placer. In total, 1,169,390 ounces (36 251 090 g) of gold were produced from about 65 locations.

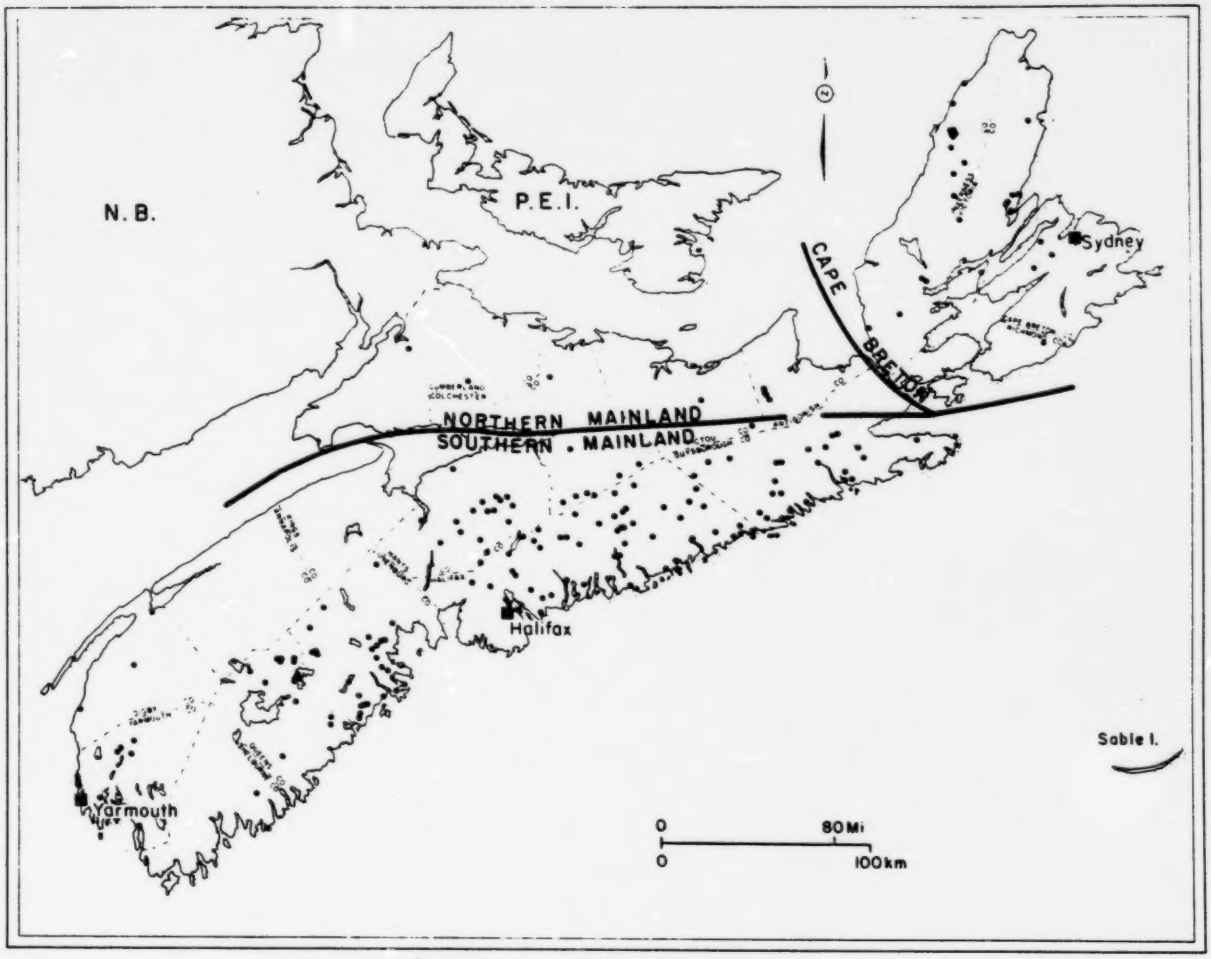


Figure 1. Gold occurrences.

Figure 1 shows that the majority of the occurrences, 144 in all, occur in the southern Mainland; most of these occur within metasedimentary rocks of the Meguma Group. At almost every site, significant amounts of detrital gold occur in the unconsolidated glacial materials overlying the auriferous lodes. At some locations, auriferous drift was mined at a profit, but volumes of this rich material were small.

Nova Scotia contains a considerable number of placer gold occurrences in alluvial and marine sediments (Fig. 2). These occurrences formed as a result of erosion and reworking of auriferous bedrock and unconsolidated glacial material. Examples illustrating the different types of

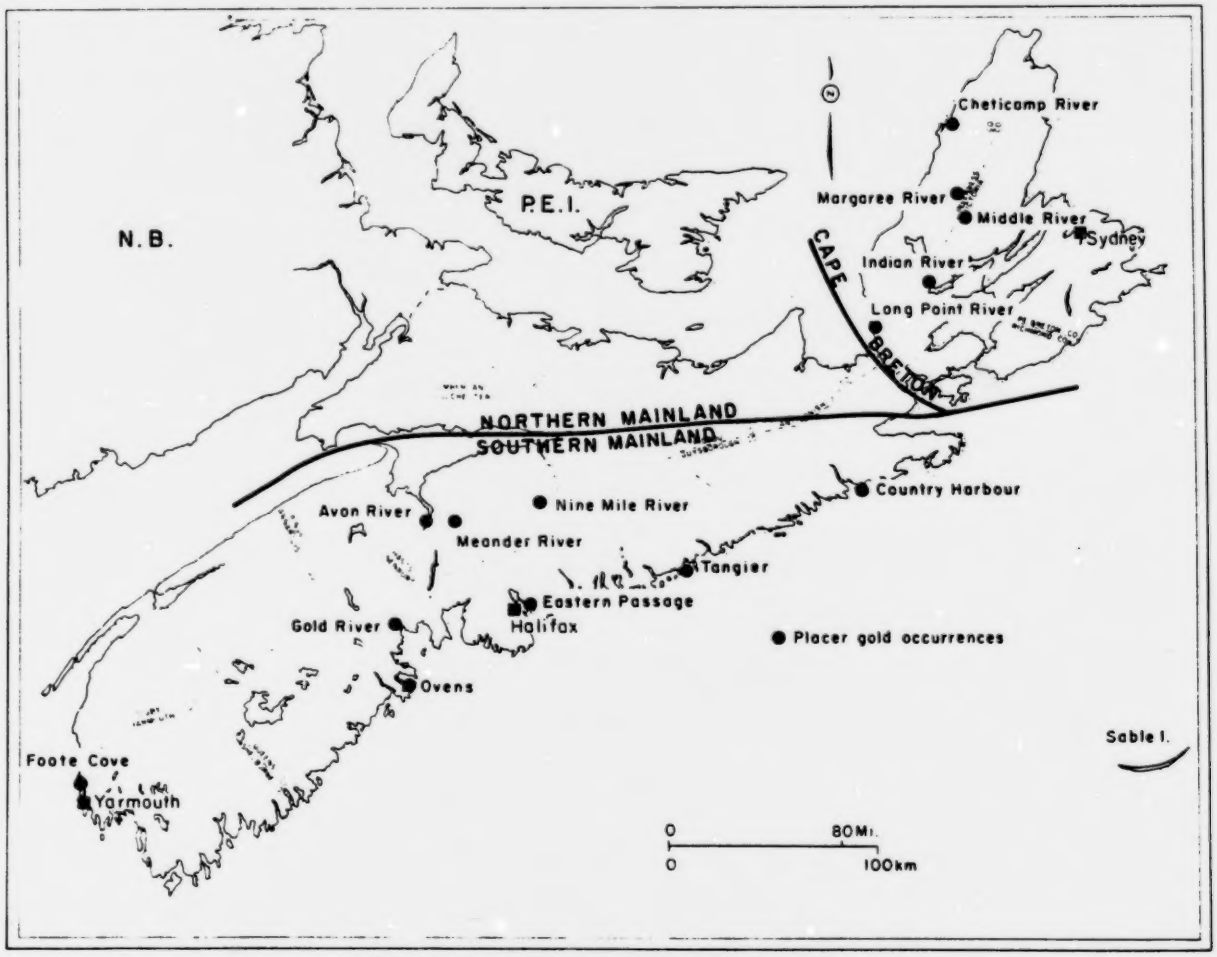


Figure 2. Placer gold occurrences.

reworked glacial materials that have concentrations of gold are: Recent fluvial at Meander River, beach at the Ovens, and gold has also been recovered from glaciofluvial materials at Nine Mile River.

Paleoplacer concentrations of gold have been found within consolidated clastic sedimentary rocks of Early Carboniferous age formed by erosion of Meguma Group rocks. The erosion and reworking of the older auriferous rocks may have continued during the remainder of the Paleozoic and into the Mesozoic.

GLACIATION

The last glaciation in this region began approximately 100,000 years ago. By the year 50,000 BC the landmass now consisting of present-day Nova Scotia and the offshore region to the edge of the continental shelf was ice-covered. At that time, much of the world's water budget was concentrated in massive continental ice sheets; the effect was to lower sea levels and depress the landmass from the weight of the ice.

This initial period of glaciation was followed by a period of melting, rising water levels and ice retreats and advances, and deposition of extensive till deposits and glaciomarine sediments throughout the shelf region. A submarine moraine complex on the continental shelf (King, 1970) is evidence for a late ice advance during this period.

With continued recession, the shelf began a period of isostatic rebound and sea level was lowered by approximately 120 metres relative to present day levels. Earlier glacial and glaciomarine deposits were reworked by wind, waves and meltwater-fed rivers to form extensive deposits of sand, sand and gravel and clay and silt.

The period that followed was marked by rising sea level when high energy beach activity cleaned and sorted earlier glacial sediment into extensive deposits of sand and gravel. The banks were submerged entirely, except for Sable Island. Ancient river channels which had been incised into the shelf were drowned. Except where water depths less than 25 metres allow sediment to be moved today, the offshore sediments have been distributed very little by natural processes since that time.

Studies on the glacially derived materials of Nova Scotia date back to the early 1800s. Prospectors learned the glaciers had not dispersed gold very far from the source lodes. This fact was not quantified until almost a hundred years later by Grant (1963), who concluded that the composition of the glacial detritus has a close relationship to the underlying bedrock. He noted some overlap of the detritus on adjacent rock-types and that there is a foreign red till that forms the drumlins. For the Southern Mainland, he noted that the locally derived tills were comprised of the three dominant rock types, graywacke and slate of the Meguma Group, and granite. The foreign red till was believed to have been derived from sedimentary rocks of the Bay of Fundy area and beyond. Stea and Fowler (1978, 1979) and Stea and Grant (1982) mapped the boundaries of these till units and determined that each has its own characteristic geochemical signature.

The offshore surficial geology has been mapped by King (1970, 1972); Fader et al (1977); King and MacLean (1971); and King et al (1974). The map units developed by King (1970) are based on the distinct character, traceability and mode of formation of sediments. Although King did not map

on the basis of the provenance of the clasts in the materials, he noted that graywacke, slate and granite were the dominant rock types off the south and eastern shores of the Province. These sedimentary sequences are flat-lying and rest unconformably upon the underlying bedrock. King et al. (1974) and King and McLean (1976) outlined the distribution of rock-types that comprise the bedrock lying beneath the surficial materials (Fig. 3). Figure 3 illustrates that rocks of the auriferous Meguma Group have an areal extent offshore comparable to that onshore.

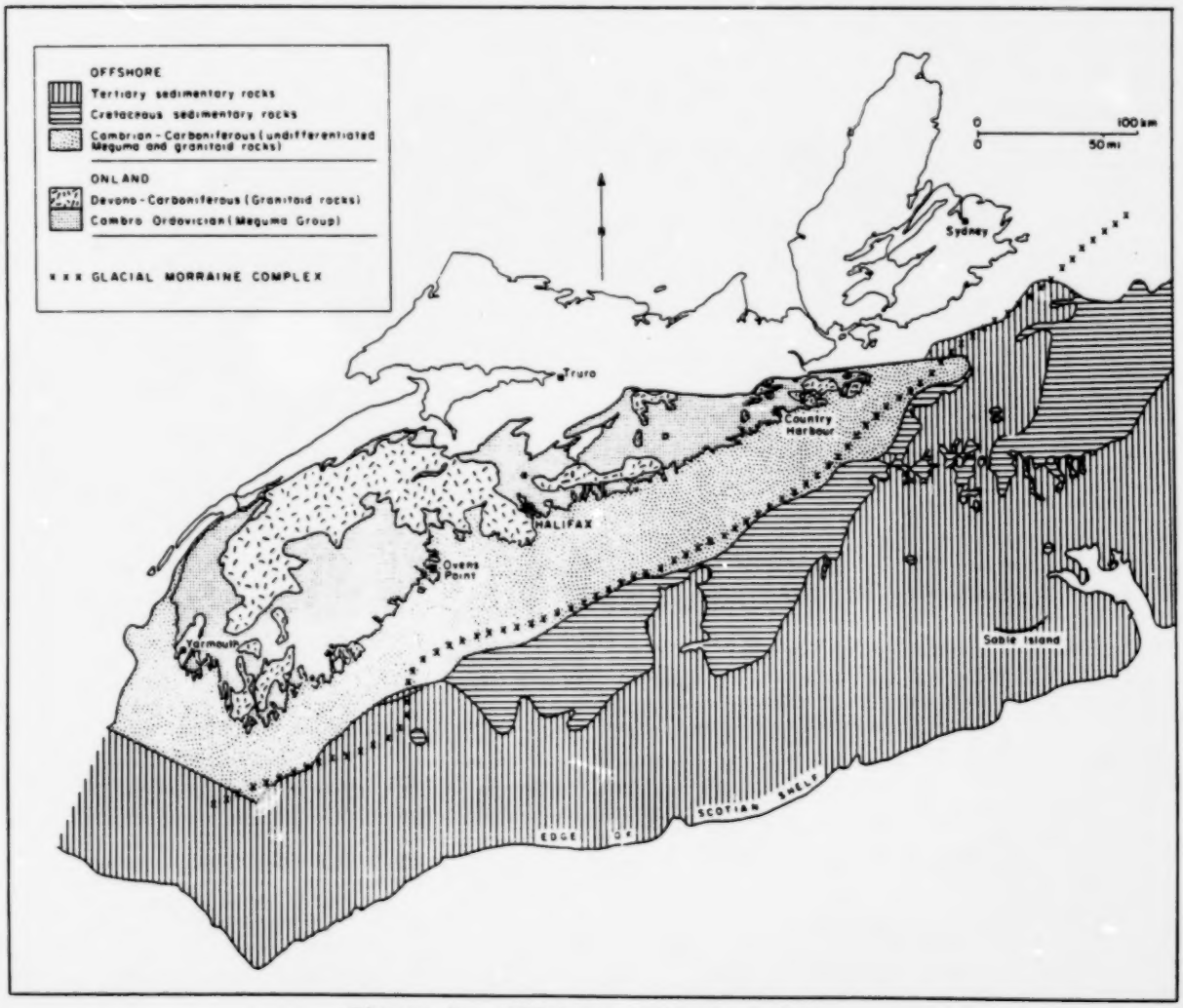


Figure 3. Offshore bedrock geology.

THE OFFSHORE RESOURCE POTENTIAL FOR GOLD PLACERS

The distribution of the auriferous rocks of the Meguma Group, both above and below sea-level, and the effects of glaciation indicate that the area of the Scotian shelf bounded to the west by Georges Basin and to the east by the Laurentian Channel is worthy of consideration for offshore placer deposits of gold.

On the basis of onshore information, geologic situations that might be expected to contain gold offshore are:

1. submarine bedrock lode deposits on anticlinal folds in rocks of the Meguma Group;

2. unconsolidated glacial tills in close proximity to (1) above that may or may not have been reworked;

3. glaciofluvial materials derived from (1) and (2) above;

4. paleoplacer gold in clastic sedimentary rocks of Tertiary and Cretaceous age derived from the erosion of (1) above; and

5. preglacial alluvial deposits that may exist beneath the cover of (2) and (3) above. If significant amounts of preglacial auriferous gravels existed, such materials, if reworked and not diluted by glaciation, could have resulted in placer concentrations.

LODE DEPOSITS

Rocks of the Meguma Group and intruding granite are considered to extend from shore under the Scotian Shelf for about 30 miles (48 km) (Fig. 3) which corresponds to an area offshore for these rocks of about 9500 square miles (24 600 sq. km) (King and MacLean, 1976). This compares to about 10,250 square miles (26 550 sq. km) onshore area of which 60 percent is composed of rocks of the Meguma Group. Large areas of granite are interpreted from geophysical data to exist offshore (Hood, 1966). If the ratio of Meguma to granitoid rocks is the same offshore, there should exist a minimum of about 50 favorable sites for gold mineralization of comparable size to the same number of former gold producing areas onshore. This fact is more important as a source for detrital gold, rather than as a target for subsea lode gold mining.

UNCONSOLIDATED GLACIAL TILLS

The terminus of the last major ice advance is marked by a series of moraines 150 feet (46 m) high by 2.5 miles (4 km) wide by 260 miles (416 km) long (King, 1970). The line of moraines occurs at about the offshore limit of rocks of the Meguma Group (Fig. 3).

Landward of this terminus, the unconsolidated materials deposited by the glaciers are probably comparable to those deposited onland and described by Grant (1967) and others. As these materials reflect closely the underlying bedrock, the glacial tills derived from auriferous lode deposits should be enriched in gold. The gold content of these tills may

have been concentrated by post-glacial eolian and the subsequent transgressing sea that sorted and winnowed the tills into the clay, sand and gravel units mapped by King (1970). Work by MacEachern (1985) indicates that most of the gold in the tills of his study area is in the -230 mesh size fraction,suggesting that some of the gold is fine-grained enough to be winnowed along with the silts and clays. As well, gold may have been concentrated deeper in the stratum next to bedrock or an impervious horizon caused by gravity settling in a high energy shoreline environment.

An economic appraisal of this type of deposit is given in a subsequent section.

GLACIOFLUVIAL DEPOSITS

Gold may have been concentrated in eskers derived from fluvial systems within the glaciers, or from fluvial systems flowing from a melting ice mass. The gold would be expected to have concentrated at the lower levels of these river beds by gravity settling in a very high water-volume and energy fluvial system. Gold concentrations may have been derived from one or more enriched till sites and from the erosion of bedrock. Such deposits could occur both landward and beyond the limits of the terminal moraines. If such fluvial systems, with gold in suspension, emptied into a glaciolacustrine environment, concentrations of gold may have resulted from the reduction in energy level of the river.

PALEOPLACER DEPOSITS

Concentrations of gold are likely to occur in the consolidated clastic sediments of Cretaceous and Tertiary age (Fig. 3), that were derived from erosion of the Meguma Group rocks. However, significant erosion of the Meguma Group during these times is unknown. Onshore Cretaceous deposits once were over 2000 feet (600 m) thick (Hacquebard, 1984), and now remnant inliers of silica sand deposits are not considered to have been derived from erosion of the Meguma Group (Gordon Dickie, in press). Stea and Fowler (1981) have noted values as high as 240 ppb Au, 737 ppm Sn and 3-10% Ti from a heavy mineral separate of a composite sample of silica sand from the Cretaceous age deposit at Brazil Lake, Hants County.

PRE-GLACIAL PLACER DEPOSITS

The possibility exists that alluvium from pre-glacial channels and streams survived the glaciation. Such deposits would now be buried under the post-glacial sediments and tills.

ECONOMIC BASIS FOR OFFSHORE PLACER EXPLORATION

Prerequisites for the formation of placer deposits on the Scotian shelf have been met. Glaciation from the auriferous rocks of the Meguma Group contributed significant amounts of unconsolidated materials blanketing the ocean floor of the shelf. There is no doubt that placer gold exists

offshore, but is there enough to call it a resource worthy of exploration consideration? The following discussion attempts to address this question.

The line of moraines marking the terminus of the last ice advance nearly coincides with the seaward extent of rocks of the Meguma Group (Fig. 3). Therefore, prior to the transgression of the sea, the glacially-derived unconsolidated materials landward of the moraines probably were very similar to the glacial tills seen onland today, but without extensive vegetation cover. The slate, quartzite and granite tills of Nova Scotia are generally thin, having thicknesses of between 3 (0.90 m) and 12 feet (3.65 m). In areas of drumlins, the tills can be 75 feet (23 m) thick (Stea and Fowler, 1978). Offshore, King (1970) describes the sedimentary units as generally being thin, but local thicknesses exceeding 250 feet (76 m) are known. It is difficult to draw any conclusions about the nature of the bottom sediments seaward of the moraines. The following is an analysis of the gold potential for the area of the Scotian shelf between high water mark and the line of moraines. It is assumed that placer mining or exploration programs would initially prefer near shore targets.

The largest and most productive gold district in Nova Scotia was at Goldenville, Guysborough County, where in excess of 200,000 ounces (6 200 000 g) of gold were produced to a depth of 500 feet. This production amounts to about eighteen percent of the Province's total gold production. The veins exploited occupied an area 6000 feet (1800 m) by 2000 feet (600 m). Within this area, five percent of the total rock volume is composed of quartz vein material and auriferous sediments, of which ten per

cent of this favorable rock is estimated by the writer to be significantly auriferous. The average grade for the milled ore was 0.50 oz./ton (17 g/tonne). Using this information, it can be calculated that the above area would contain 445,000 cubic yards (340 000 cubic meters) (1 million tons - 0.90 million tonnes) of rock per foot of depth. The grade of this volume would be 0.0025 ounces per ton (.085 g/tonne), or about 2500 ounces per foot of depth (254 200 g per metre of depth).

If within the above area the locally-derived till cover has an average 15 ft. (4.6 m) depth, there would be 6.7 million cubic yards (5.13 cubic meters) of auriferous unconsolidated material (11.7 million tons; 10.6 million tonnes), the equivalent of 11.7 feet (3.6 m) of erosion. This volume of till would be expected to contain about 30,000 ounces (930 000 g) of gold freed by the glacial comminution of 11.7 feet (3.6 m) of bedrock.

The 30,000 ounces (930 000 g) of gold would have undergone down-ice dispersion in an onlapping form for at least 2000 feet (610 m). The effect of the dispersion would be to approximately double the volume of material now required to recover the 30,000 ounces (930 000 g) of gold, since the area of interest is now 6000 feet long by 4000 feet (1800 x 1200 m) wide. The grade would now be 0.00125 ounces per ton (0.04 g/tonne), or $US0.40 per cubic yard ($US 0.31/cubic meter) with gold at $US 320.

If we assume that there are fifty such lode gold deposits within the area of the sea bottom underlain by rocks of the Meguma Group, of comparable size to Goldenville, the total volume of gold that could be expected to occur landward of the moraine complex in tills would be 1.5

million ounces (46.5 million g). However, this assumption is unlikely and the total volume of gold freed by glaciation and deposited in tills offshore is probably considerably less.

Sufficient information is unavailable to do similar calculations for other geologic environments discussed in a previous section.

CONCLUSIONS

1. Conditions are favorable offshore for the formation of placer gold deposits on the Scotian shelf.

2. The amount of gold in a given deposit will be dependent upon the volume of auriferous rock eroded. This will be a function of the depth to which glaciers comminuted the bedrock and the volume of auriferous material available for erosion. The total depth of rock eroded by the many ice advances is unknown.

3. Primary or reworked glacial tills adjacent to their auriferous bedrock sources have potential for placer deposits but such individual deposits may be of limited size, especially landward of the series of moraines.

4. Other minerals found onland in significant quantities having placer potential are cassiterite, scheelite, ilmenite, garnets and zircons.

5. Marine mining of placer minerals may best be done as a by-product to aggregate dredging operations.

6. The greatest potential for sizeable marine placer deposits may lie in drowned river channels such as the old Sackville River off Halifax Harbour between the moraines and the edge of the shelf. These targets probably exist both landward and seaward of the moraines. Outwash deposits seaward of the moraine, if they exist, may have gold potential as well.

AGGREGATES

INTRODUCTION

The consumption of aggregates in Nova Scotia began several hundred years ago and has evolved into a 55 million dollar industry employing 700 people. Annual production is about twelve million tonnes. Throughout the production history, adequate, indigenous resources have provided all of the aggregates materials required to meet provincial needs and supply continuously increasing volumes to export markets in other eastern Canadian provinces, the southern United States and Bermuda.

Generally, as is the case in many other regions, there is some concern being expressed by the aggregate industry about the availability of high quality materials needed to supply expanding markets. Verification of this concern was well illustrated in 1978 when the Department of Mines and Energy completed a province-wide sand and gravel inventory mapping program

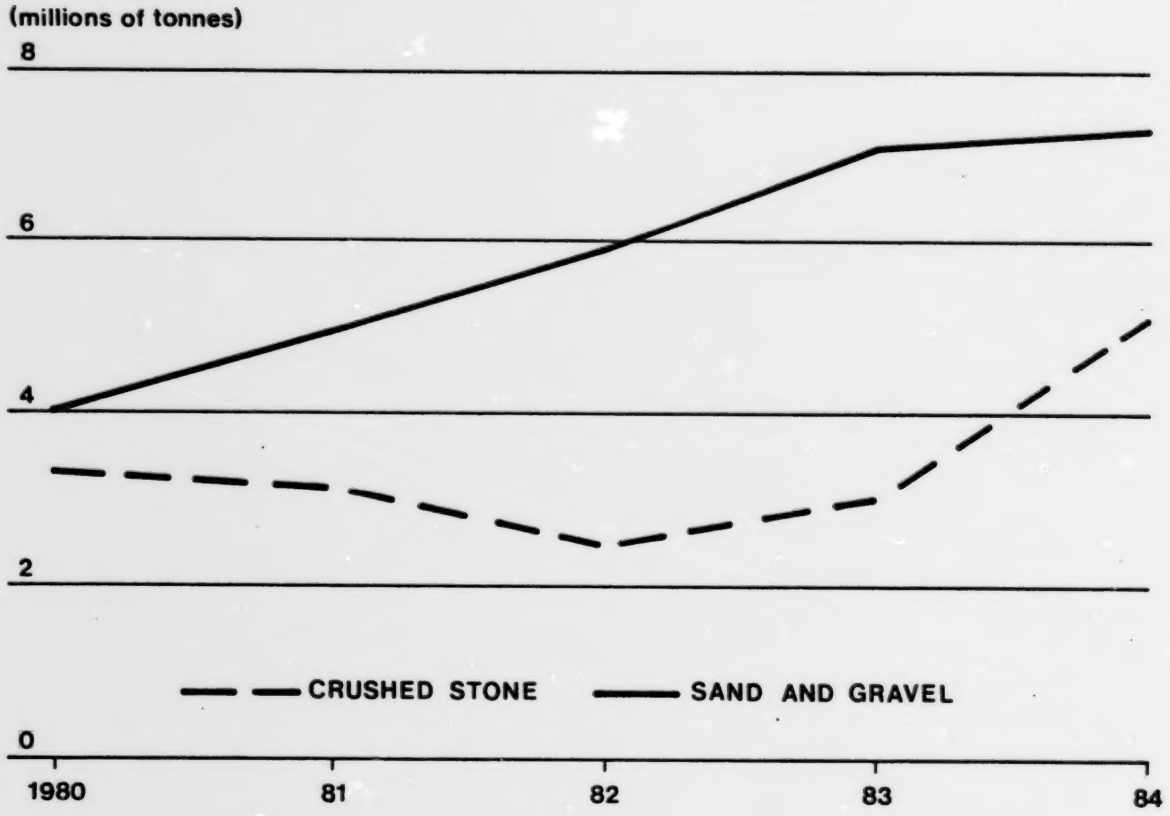


Figure 4. Aggregate production in Nova Scotia from 1980 to 1984.

identifying regions of the Province where sand and gravel deposits are scarce or of poor quality. The intense extraction activities of many of the known deposits and other land uses which have been applied to areas underlain by aggregate materials, have created a value awareness of aggregates hitherto unannounced. Even though there are now no acute shortages of aggregates in Nova Scotia, many producers are interested in finding new deposits for future needs.

To properly evaluate the development potential of a new source of aggregate, such as offshore deposits, several factors have to be considered: first, an acceptable economically mineable resource has to be well defined and secondly, efficient transportation systems must be identified to move these materials into the marketplace at competitive prices.

The following characterizes the current aggregate industry in Nova Scotia in relation to resource availability, production capability, markets and transportation methods; which are necessary criteria for assessing the development potential of offshore aggregate deposits to service local markets.

HISTORY OF MARINE SAND AND GRAVEL MINING

Nova Scotia is a coastal Province with numerous bays, inlets and near shore islands where sand and gravel beaches are plentiful. Early settlers to the coastal region used beach sand and gravel to satisfy their aggregate needs.

It soon became apparent that some beaches were capable of providing large quantities of superior quality sand and gravel and a market existed in larger centres. Many of the islands in Mahone Bay, west of Halifax, were well known for their excellent beach sand deposits, and in the mid to later part of the last century a fluorishing sand trade developed between the Mahone Bay Islands and the city of Halifax. Sand was loaded on schooners by hand and shipped to Halifax to make concrete used in

many early structures including the first dry dock at the Halifax shipyard which opened in 1889 and is still used today.

In Halifax Harbour sand and gravel dredging around McNab's Island continued until the mid 1970s. At the height of activity as many as seven operations produced up to 1000 tons per day, all for the Halifax-Dartmouth market. These operations consisted of cranes equipped with clams for loading scows which were pulled by tug to Halifax and Dartmouth.

A rail line, running east of Halifax and passing close to several large beachs, also served to transport sand and gravel to markets in Dartmouth and Halifax.

Not only in the Halifax area but in most areas of Nova Scotia, beach mining was a common practice until the 1950s when concern was expressed about deteriorating beach conditions resulting from mining. For the next twenty-five years activity slowly subsided with inland deposits becoming more active. Today intermittent beach sand and gravel mining is permitted at one location on Cape Breton Island.

A gradual shift away from marine aggregate mining (dredging) in Halifax Harbour began in 1954 when the development potential of a large inland esker sand and gravel deposit at Shubenacadie (65 km north of Halifax) was recognized. Production began that same year with the company promoting sales by advertising their sands and gravels as being clean, fresh water washed material. This company, although under different owner-

ship today, continues to operate from this same location and is a major sand supplier to the Halifax-Dartmouth market.

Another significant development in the 1950s was the surficial mapping program initiated by the Nova Scotia Research Foundation. For the first time, a series of surficial maps were available to the public and these were used extensively by the aggregate industry to locate aggregate deposits. In the 1960s, public pressure mounted against operators mining beach deposits and the Provincial Government took action to either forbid or control sand and gravel extraction from beaches. Public pressure continued into the 1970s at which time the Nova Scotia Department of Mines began a Province wide sand and gravel inventory mapping program. In 1975 the Beaches Preservation and Protection Act was proclaimed and serious concern was expressed by supply companies. It was strongly suggested that closing the beaches would create serous aggregate shortages and may even put some operations out of business.

The planned gradual enforcement of the Beaches Preservation and Protection Act by the Nova Scotia Department of Lands and Forests, the resourcefulness of aggregate operators, and the information and technical assistance provided by the Nova Scotia Department of Mines and Energy and the Nova Scotia Research Foundation, helped minimize the effect of beach closure.

AGGREGATE RESOURCES

Aggregate resource studies have shown that Nova Scotia has extensive deposits of both surficial, granular materials and bedrock aggregate (Fig. 5).

Surficial deposits supplying acceptable aggregates are tills with a sandy matrix and durable clasts, ice-contact deposits and outwash deposits. Ice contact and outwash deposits are used extensively while tills remain minor contributors to the aggregate budget of the Province. The quality of these granular deposits ranges from unacceptable to excellent.

Extensive bedrock regions of the Province have excellent aggregate development potential. Currently large volumes of high quality aggregates are produced from the Cambro-Ordovician Goldenville Formation quartzites and Devonian plutonic rocks. In the Halifax-Dartmouth region where sand and gravel deposits do not occur, bedrock quarries supply most of the aggregates.

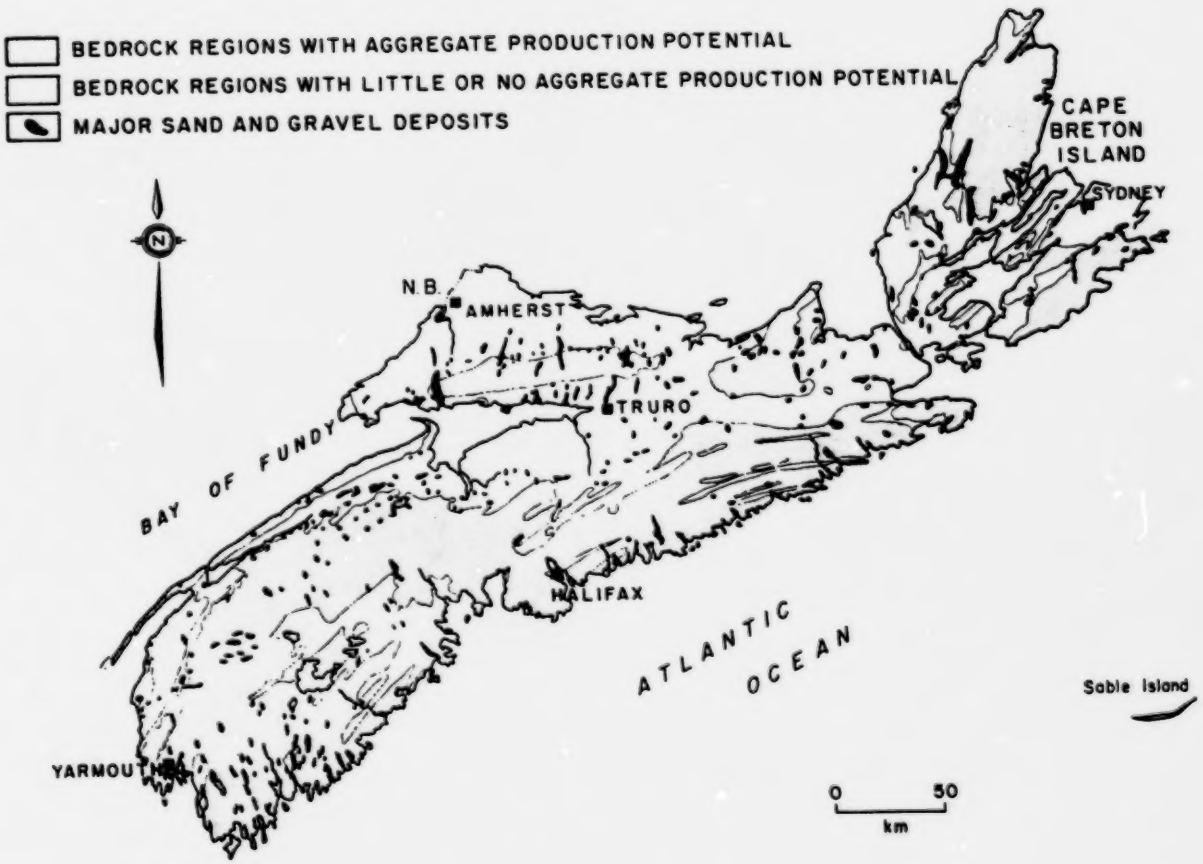


Figure 5. Distribution of granular and bedrock aggregate resources in Nova Scotia.

Although there are no acute shortages of aggregates in the Province, there are regions where aggregate supplies are in limited supply or of insufficient quality for concrete or asphalt. In these regions, aggregates are brought in, usually by truck, to satisfy the market.

PRODUCTION, CONSUMPTION AND TRANSPORTATION

Aggregate production for 1984 in Nova Scotia amounted to over 12 million tonnes of which 1 million tonnes were exported and 11 million tonnes were consumed within the Province.

The major consumer was the Nova Scotia Department of Transportation for highway and road construction, improvements and maintenance. The bulk of this work is done by roadbuilding construction firms through a public tender process. Most of the aggregate used for highways comes from surficial granular deposits occurring in the contract area.

Halifax-Dartmouth, at over 3 million tonnes consumption, is the Province's major production-consuming aggregate centre followed by Sydney, and several smaller centres of the Province (Fig. 6). Figure 6 also shows high production regions where local consumption is low with most shipments going to other regions of the Province or to export markets. Two companies ship significant volumes out of the Province, one producer at Folly Lake, Cumberland County ships crushed rock railway ballast as far as southeastern Quebec and granular aggregate materials to Prince Edward Island. Most shipments are by rail. At Aulds Cove, Guysborough County, at the Strait of Canso, another producer ships crushed rock to Prince Edward Island by barge and uses self unloading vessels to move shipments ranging from 10,000 tonnes to 50,000 tonnes to markets in Georgia, Florida and Texas.

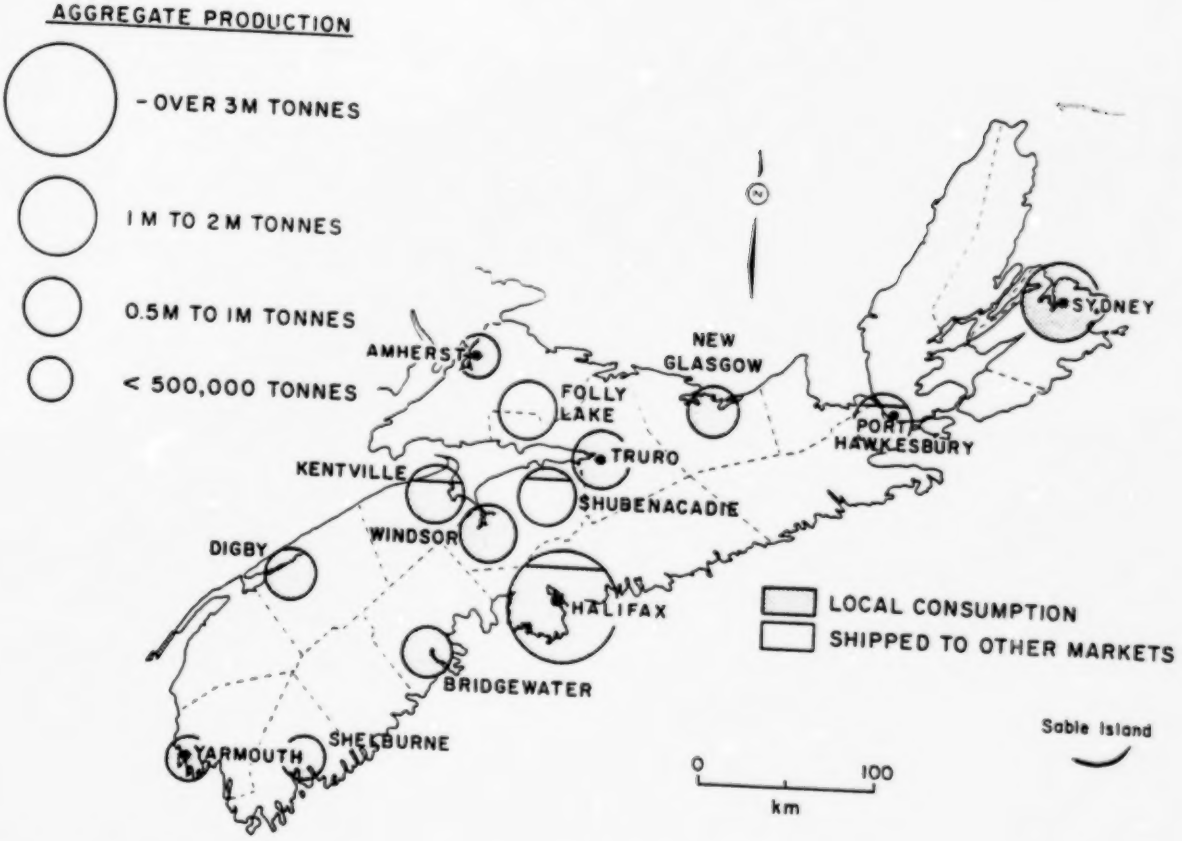


Figure 6. Major aggregate production and comsumption centers in Nova Scotia.

Aggregate production in the Halifax-Dartmouth region comes from five quarries rimming the metropolitian area. Quarry output ranges from a low of 60,000 tonnes to a high of 1.3 million tonnes. All concrete, mortar and some asphalt sand is trucked from Shubenacadie (65 km north of Halifax) and Coldbrook (115 km west of Halifax).

In Sydney, most of the aggregate production comes from the Meadows Road sand and gravel deposits, 15 km southwest of Sydney and a quarry at Leitches Creek, 25 km northwest of Sydney. Recently, new deposits of surficial and bedrock aggregates, have been identified and production started.

In most other regions of the Province, sand and gravel deposits provide the bulk of aggregate materials. However, new quarries are being developed in regions where these deposits are scarce or unacceptable for concrete or asphalt usage.

PRODUCTION AND TRANSPORTATION COSTS

Aggregate producers, faced with increasing production costs, have taken steps to improve the efficiency of their operations in order to remain competitive. The latest production costs for concrete and asphalt aggregates mixes, which are sized and washed before shipping, range between $2.75-$3.00 per tonne for sand and gravel and $3.25-$4.50 for crushed stone. Production capability of the industry is presently not at full capacity.

Figure 7 shows the transportation pattern of aggregates produced in Nova Scotia, both for local and export markets. Within the Province all shipments are moved by truck while shipments to markets in New Brunswick, Prince Edward Island and Quebec are by truck, rail and barge. Shipments to the southern United States are moved in modern, self unloading vessels with carrying capacities ranging between 10,000 and 50,000 tonnes.

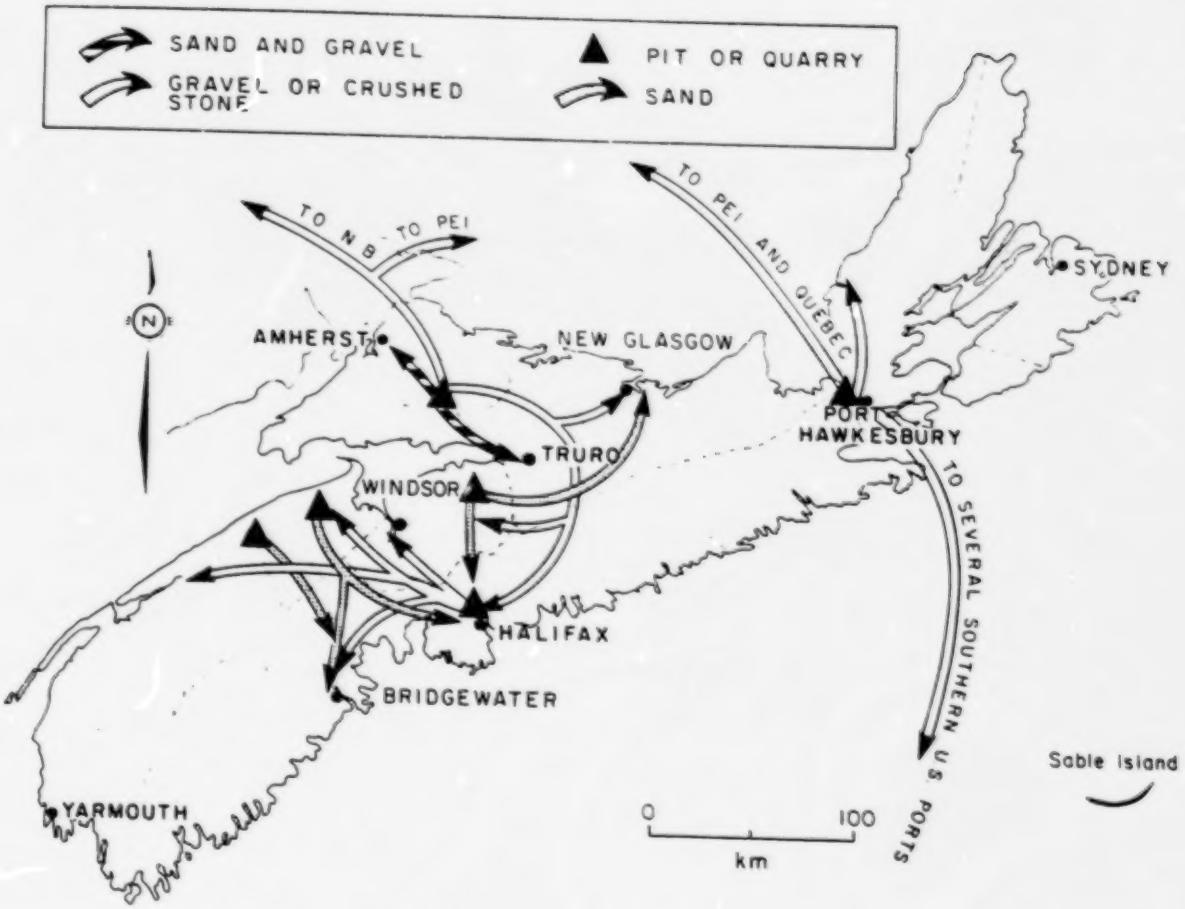


Figure 7. Long haul aggregate transportation patterns.

Truck transportation costs for aggregates are variable. The Nova Scotia Department of Transportation has established haulage rates for trucks operating with full loads. An extract from this rate schedule is Table 1.

Table 1. Department of Transportation haulage rates.

Tonne Kilometre Rates	
Distance-Kilometer	$/tonnes
1	0.70
2	0.83
3	0.96
4	1.08
5	1.22
10	1.86
20	3.15
30	4.43
50	5.53
75	6.75
100	8.05

For aggregate companies hiring trucks to move large volumes of aggregates, the rates are negotiated and usually substantially lower than Department of Transportation's rates and on occasion, two-way hauls are available, again lowering transportation costs.

FIXED AGGREGATE MARKETS

Thus far, the discussion has looked at the historical development and the overall structure of the aggregate industry in Nova Scotia, now for a closer examination of the fixed aggregate markets in the larger market centres of the Province. Fixed aggregate markets include concrete ready-mix plants, concrete block, pipe and other structural products plants and stationary asphalt plants. It is assumed that a market study to assess the

development potential of an offshore aggregate mining operation would initially examine these local, fixed, steady markets.

The locations of concrete, and fixed or stationary asphalt plants in Nova Scotia are shown on Figure 8. The largest concentration of these operations is, for obvious reasons, in or near Halifax-Dartmouth. Figure 8 shows the amounts of aggregates needed to satisfy fixed markets in several centres in the Province. Halifax-Dartmouth consumes just under 600,000 tonnes/yr., followed by Sydney at 160,000 tonnes/yr.

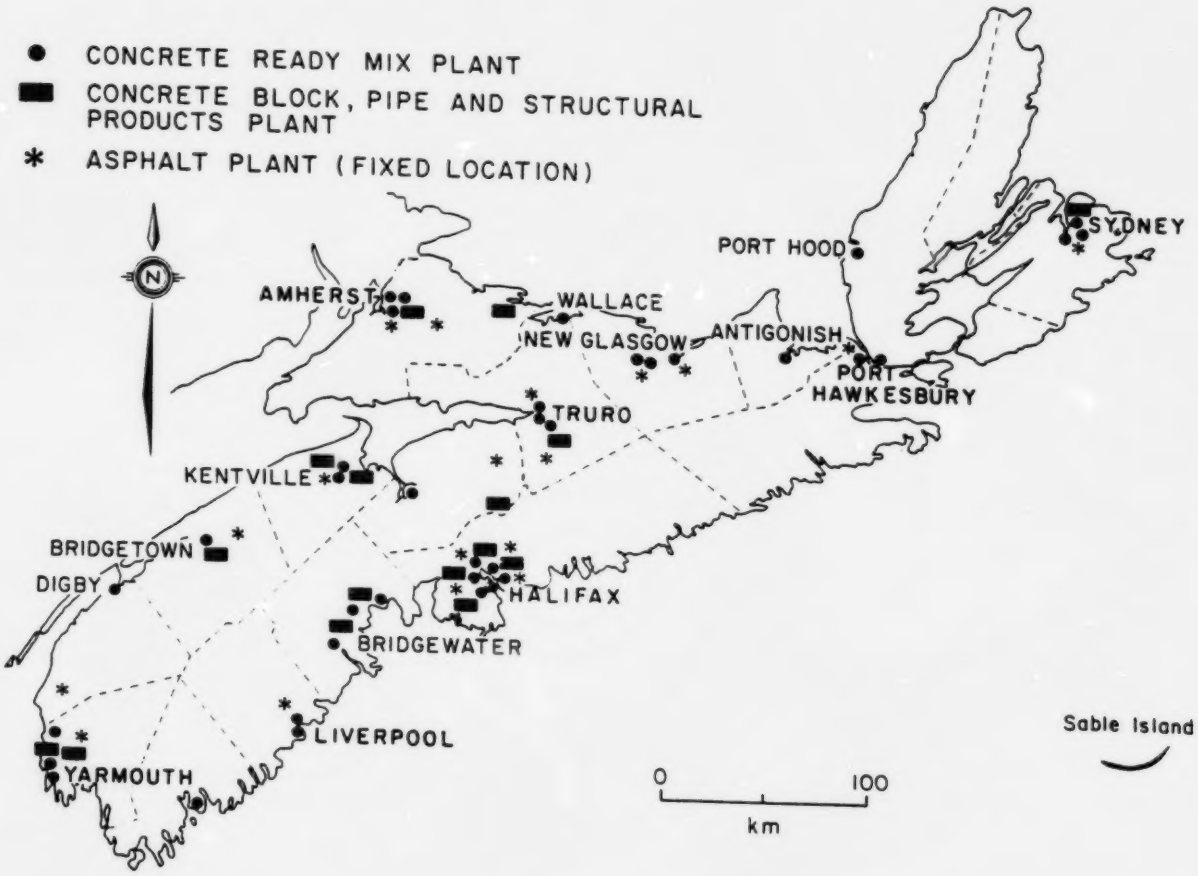


Figure 8. Locations of concrete and stationary asphalt plants.

In Halifax-Dartmouth, as is the case in most of the other centres, the fixed market consumption is only a fraction of the total consumption. Most of the aggregate materials used in towns and cities goes for street and road construction, sewage projects, commercial site preparation, parking lots, residential uses, including foundation preparation and drainage uses, and backfill projects. These markets, although very significant, are more difficult to predict.

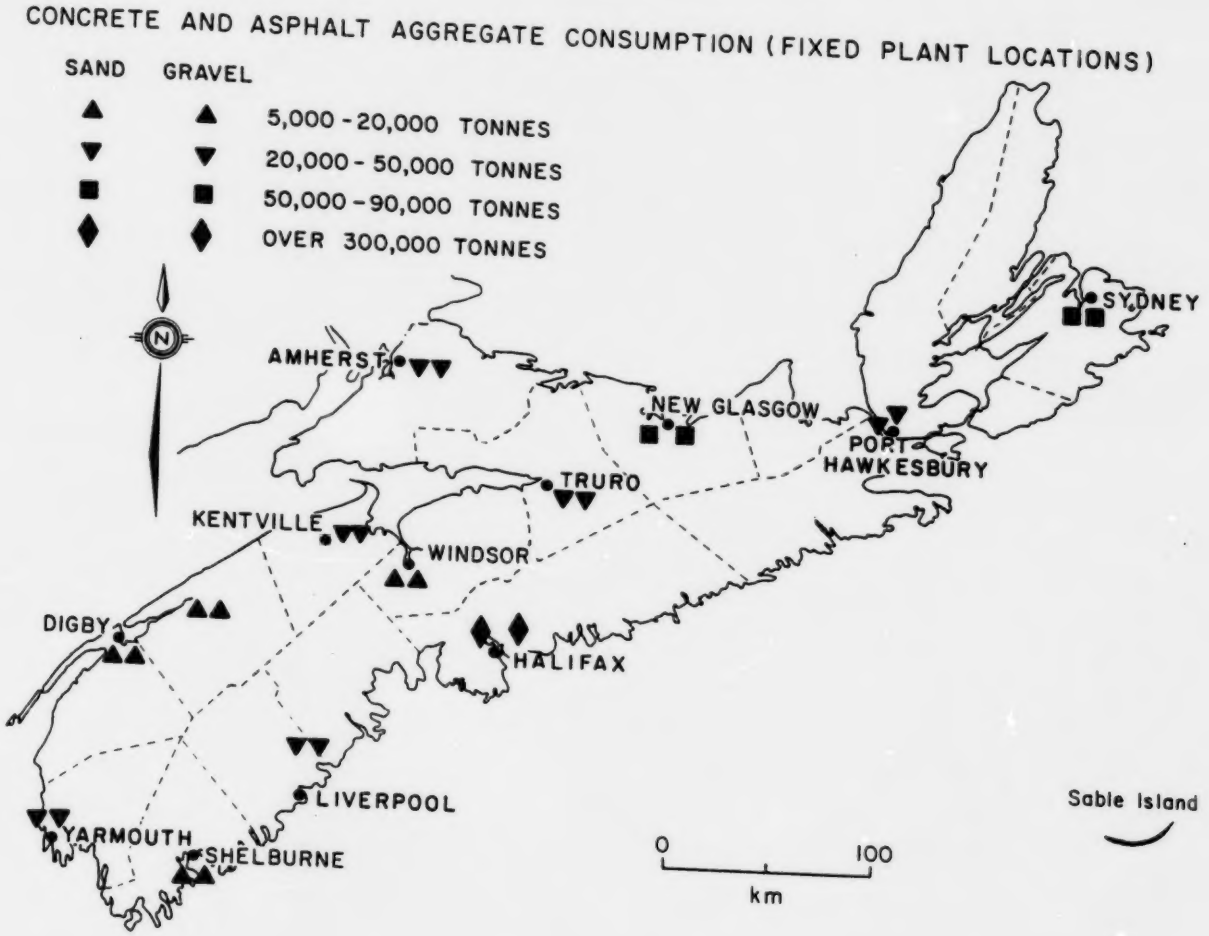


Figure 9. Sand and gravel consumption by concrete and stationary asphalt plants.

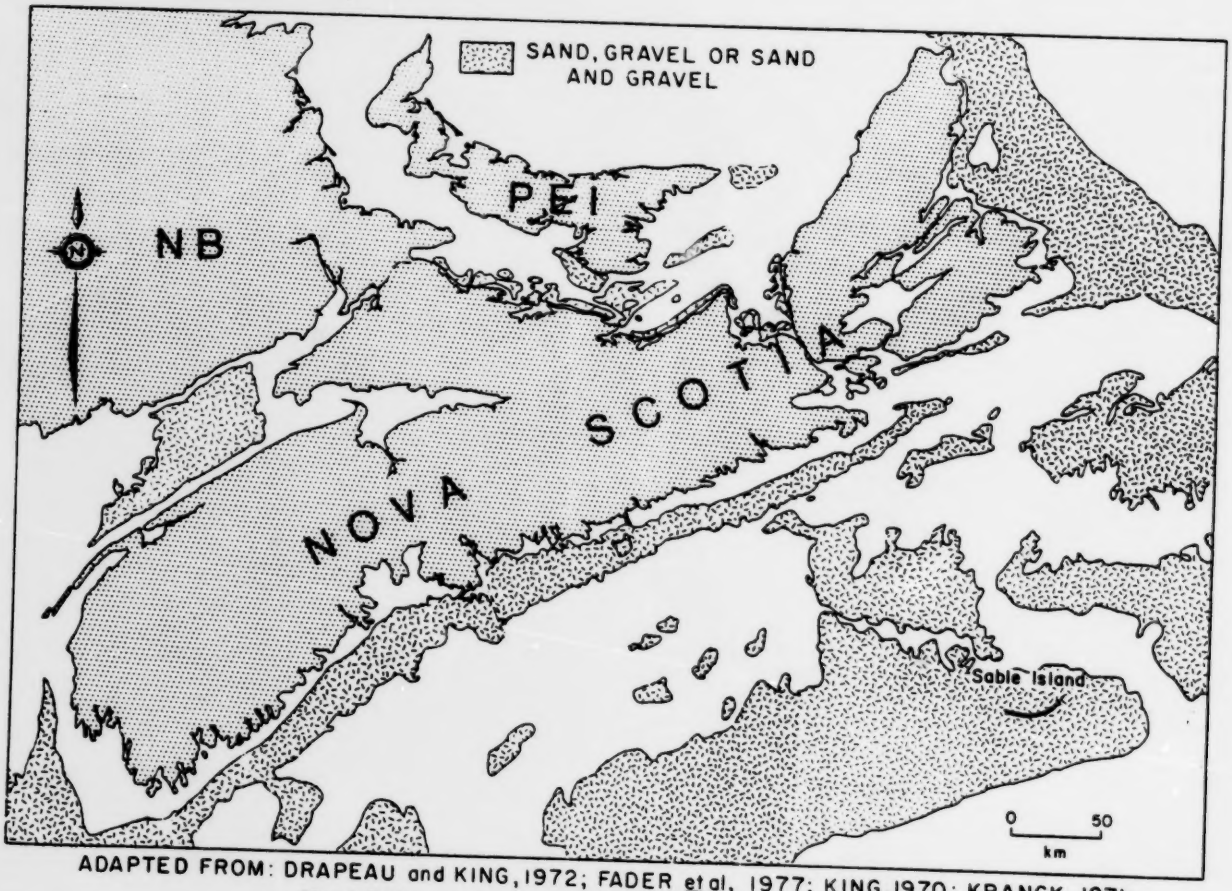
Concrete ready-mix, structural concrete plants and asphalt plants in the Halifax-Dartmouth have been established in close proximity to the quarries supplying the bulk of the aggregate. However, sand consumed by these operations has to be delivered from deposits 60 km and 115 km from plant sites. The amount of sand trucked into Halifax-Dartmouth for these plants is in the order of 300,000 tonnes/yr. Concrete and asphalt aggregates consumed in the Sydney area come from nearby deposits with the exception of a small amount of concrete sand coming off a beach 40 km south of Sydney. In the other smaller centres, concrete and asphalt aggregates are obtained locally or are supplemented with shipments of high quality aggregates from other areas.

DEVELOPMENT POTENTIAL OF OFFSHORE AGGREGATE DEPOSITS

It is certain that good quality aggregate deposits exist in the offshore. These deposits were developed by reworking processes including high energy beach action subjected to earlier glacial deposits in a transgressing sea environment. These processes served to clean and sort the tills, and destroy soft, deleterious materials, leaving clean sand and gravel deposits ranging in thickness from less than one metre to fifty metres.

Onland aggregate resources in Nova Scotia are capable of supplying the fixed concrete and asphalt market, the general use aggregate market, the roadbuilding aggregate market and a developing export market. Because there are no shortages in the Province, offshore aggregate would have to be delivered to consumers at competitive prices in order to obtain

market penetration. There is no way of knowing how competitive offshore aggregate could be in the local market until mining, transportation and marketing feasibility studies are available.



ADAPTED FROM: DRAPEAU and KING, 1972; FADER et al, 1977; KING, 1970; KRANCK, 1971; MacLEAN and KING, 1971 and MacLEAN et al, 1977.

Figure 10. Distribution of sand and gravel deposits in the Offshore.

The steps which could be taken to promote offshore aggregate development are as follows:

1. Define the nature and size of high quality aggregate deposits in water depths where dredges could operate. This study should also address all environmental and fishery sensitivities.

2. Determine if these deposits contain other minerals such as gold that could be recovered during extraction of the aggregates and thereby enhance resource development opportunities.

3. Complete a study to identify extraction, transportation, offloading and delivery costs once suitable deposits have been identified.

4. Examine aggregate markets extensively to include all possible areas that could be served by our offshore deposits.

5. Keep the aggregate industry informed on what is happening with offshore aggregate deposit studies.

Two studies currently underway will be useful for assessing the development potential of offhore aggregate deposits. Under the Canada-Nova Scotia Mineral Development Agreement and the Canada-New Brunswick Mineral Development Agreement an aggregate market study has been commissioned to identify market opportunities for Nova Scotia and New Brunswick aggregates beyond the geographical boundaries of the two provinces. A second program under the Canada-Nova Scotia Mineral Development Agreement with Canada Oil and Gas Lands Administration, Energy, Mines and Resources Canada and Mineral Policy Sector, also of EMR involvement has gone to tender. This

study will examine the effects of British sand and gravel dredging on the fishing industry and beach erosion. The information provided by this study will be useful in terms of creating an awareness of any problems resulting from offshore dredging and will serve in the design of offshore dredging feasibility studies for offshore Nova Scotia.

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PLACER GOLD AND INDUSTRIAL MINERAL RESOURCES OFF NOVA SCOTIA

Underwater Mining Institute

Field Guidebook

October 24, 1985

By

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INTRODUCTION

P. B. Hale

Marine Mining for Unconsolidated Granular Mineral Deposits

Marine mining for unconsolidated granular mineral deposits is a well-established industry around the world. Aggregates have been mined off Great Britain for several hundred years and tin has been dredged from the Andaman Sea off Thailand since 1907. Table 1 illustrates the countries that have been involved in offshore mining activities and the status of these operations. It shows that they are wide-spread and occur, not only in areas of tropical climate, but also in temperate and arctic regions. The granular commodities of commercial interest fall into two general categories: industrial minerals (e.g. carbonate sands, high-purity silica sand, and sand and gravel) and, placer minerals (e.g. diamonds, ilmenite, monazite, zircon, tin and gold). In the former, all or almost all of the mined material is utilized whereas in the latter only a small fraction, usually much less an 1%, is retained.

Marine mining in Canada is a fledgling industry dating back to early 1970s when aggregate dredging was instigated in the Beaufort Sea to construct artificial islands for oil and gas exploration. This has evolved into the largest aggregate dredging operation of its kind in ice-infested waters. Aside from the Beaufort sea operations, there have only been a few small-scale dredging operations to extract marine aggregates. A relative abundance of onland material situated close to the market which could be had for a reasonable cost, made it unnecessary to look to the

TABLE 1: Summary of golbal beach and offshore mining activities

Commodity	Country	Current Status
Industrial Minerals		
(i) Texturally dependent: sand and gravel (aggregate)	Canada; Cuba; Denmark; France; Netherlands; Japan; Nigeria; Sweden; U.S.A.; United Kingdom	Offshore exploration and mining
(ii) Composition dependent: calcium carbonate[1] (cement, agricultural lime)	Bahamas; Brazil; Cuba; Denmark; Fiji; France; Iceland; Kenya; Republic of China; United Kingdom; U.S.A.; Mauritania	previous or ongoing offshore mining beach mining
high-grade silica sand (glass)	Finland; Canada; New Zealand	offshore mining offshore exploration/evaluation mining inharbour
Placer Minerals		
cassiterite (tin)	Indonesia; Thailand; U.S.S.R.; United Kingdom; New Zealand; Australia	offshore mining offshore pilot-scale mining offshore exploration previous beach and offshore exploration
chromite (chromium)	U.S.A.; Mozambique	previous beach mining and offshore exploration previous offshore exploration
diamonds	Namibia	beach and offshore mining
gold	Canada; New Zealand; Philippines; U.S.A.; U.S.S.R.; Fiji; India	previous beach mining/offshore exploration previous offshore mining; present status unknown previous beach mining, offshore exploration and mining Offshore exploration/mining? estuarine mining operation offshore exploration
iron sands	Brazil; Fiji; South Africa; Japan; Australia; New Zealand; Florida, U.S.A.; Philippines; Mozambique; S.W. India; Sri Lanka	previous offshore mining; present status unknown beach mining previous beach and offshore mining previous beach mining previous beach mining, present status unknown previous or ongoing offshore exploration beach mining, offshore exploration
monazite (rare earths and thorium)	Australia; S.W. India; Brazil; Sri Lanka;	previous beach mining offshore exploration beach mining
phosphorite (phosphorous)	Australia; Mexico; New Zealand; U.S.A.	past or ongoing offshore exploration
platinum	U.S.A.	previous beach mining, and ongoing exploration
rutile	Australia; Brazil; S.W. India; Sri Lanka; Canada	beach mining, offshore exploration previous offshore exploration
zircon	Sri Lanka; Canada; Australia; Mozambique	beach mining, offshore exploration previous exploration previous offshore exploration

1. Includes aragonite, coral, marl and shell hash

(SOURCE: HALE AND MCLAREN, 1984)

offshore. However, the situation is quickly changing in many areas as traditional onland sources are depleted and/or excluded by zoning restrictions. Many of the populated regions in Canada are situated at or close to the coastline. As a result, the aggregate demand has been satisfied in part through beach mining. Such practice was, until recently, relatively wide-spread in Atlantic Canada.

Within the last decade, all provinces with the exception of P.E.I., have prohibited beach mining as a result of problems related to coastal erosion. Exclusion of this source of supply has added further to the problems of aggregate supply. It is, therefore, timely to consider the offshore as an alternate source that could supplement onland deposits.

ENVIRONMENTAL SETTING

Evaluation of an offshore mining prospect typically takes into account, not only the characteristics of the deposit, but also the operating environment. Failure to consider the latter can lead to financial disaster and the loss of life. Sea state, fog and ice are the major environmental factors that can significantly reduce the estimated production rate and interrupt the source of supply to the processing plant or markets. In some cases the environmental effects may be even more serious. Take, for example, the diamond dredging/processing plant which operated off Namibia, and the gold dredging system situated off the Seward Peninsula, Alaska in 1983. Both of these offshore mining systems were severely damaged during storm wave conditions.

The following section provides a regional overview of the coastal marine environment off southwestern Nova Scotia and the factors that could influence the design and logistics of a marine mining operation.

Climate

There is a marked seasonality in the weather in terms of temperature, precipitation and winds. The winter season lasts from December to mid-April and it is characterized by daily mean temperatures of 0°c or less, showers, snow flurries and gusting winds. The combination of winds ranging from 10 to 30 knots, freezing spray and fog make coastal operations hazardous during this period.

By mid-April the storm track has migrated to the North reducing the dominance of the cold polar air mass; as a result, the temperatures moderate and fog, low cloud and drizzle predominate. The spring lasts until about the end of June, by which time temperatures have increased to 18°c or above.

The fall is perhaps the nicest time of the year as there is relatively little precipitation and fog since the coastal water is now at its warmest. Daytime temperatures average around 12 - 18°c and winds are relatively light. Towards the end of the fall, the number of intensity of low pressure systems increases, bringing periods of rain, reduced visibility and high winds.

Fog

Conditions of reduced visibility (i.e. less than 9 km visibility) can lead to potentially dangerous operating conditions in areas of heavy shipping traffic. They can also create problems in situations where navigation and accurate positioning is dependent on visual observations. Operations under such conditions can also lead to the inadvertent damage of fishing gear.

Periods of reduced visibility including fog are most common in the late winter and early summer. June is the foggiest month because the coastal water is still cold causing condensation of vapour when the warm air flows over it. July and August are dominated by offshore breezes hence visibility is generally good. Come fall, the cold polar air masses shift south, so that they mix with the warm tropical air masses over the provinces. This results in increased periods of reduced visibility.

Winds

Mean annual wind speeds along the Atlantic Coast of Nova Scotia range from a high of 21 km/h in the northeast to 18 km/h in central Nova Scotia and 19-20 km/h in southwestern Nova Scotia. The mean maximum wind speed (mean during the windiest month of the year) is greatest in northeastern Nova Scotia where it averages 25 km/h. This decreases to 23 km/h in the southwest.

The dominent wind direction throughout the year is westerly, thus, given the northeast to southwest orientation of the coast and these prevailing wind conditions, the coastal zone is a sheltered leaward environment for a large proportion of the year.

The passage of meteorological depressions through the area result in the generaton of relatively high wind speeds capable of producing high wave energy conditions that could curtail or possibly even damage a marine exploration/mining operation. These storms exhibit a marked seasonal variability with most occurring during the winter months from November through to April. March is the stormiest month followed by January and February. The 6-month period from May through to October is generally storm-free.

Ice

The southshore of Nova Scotia lies outside the extreme iceberg limit but is subject to land-fast sea ice for up to 2 months (January - February) during severe ice years. The ice is usually less than 0.3 metres in thickness but can reach 0.45 metres necessitating icebreakers to keep the harbours open. Such is particularly the case during ice break-up when the wind can concentrate. The presence of ice in the coastal zone, in combination with the greater frequency of storms during the winter, will most likely force the termination of any offshore exploration/mining project that utilizes traditional techniques during this time of the year.

In some localities the ice may be used to advantage for exploration purposes close to shore as it can provide a stable platform for drilling. This practice has already been utilized with considerable success off Alaska and in some Canadian lakes. It would, however, be a short operating season requiring careful planning and coordination.

Tides

Tides along this section of coastline are microtidal in range (less than 2 metres) and of semi-diurnal type; that is there are two high and two low waters of about equal height each lunar day (24 hours and 50 minutes). Although the tides must be taken into account for exploration of intertidal zone, they are not likely to pose any constraint to offshore activities. The tidal velocities are generally low (less than 0.5 knots), and are oriented perpendicular to the coast.

Waves

This coastline is classified as a storm-wave dominated environment. Predominant winds are offshore, hence swell wave activity is non-existent.

Wave activity is confined to those periods associated with the passage of meteorological depressions and resultant high wind speeds. The intensity of wave activity is a function of both the wind speed, duration and the overwater distance subject to the high wind conditions.

Wave conditions were recorded in Lunenburg Bay using a wave-rider, accelerometer buoy in 1978-1979 (Fisheries and Oceans, 1979). The records indicate that Lunenburg Bay is relatively sheltered environment with maximum wave heights of 1.5 metres or less and associated wave periods typically between 4 and 13 seconds.

Figure 1 illustrates the per cent of time a specified wave height is expected to be exceeded. This is of particular interest to the offshore prospector/miner. If the exploration geologist is using a coring system that requires wave heights of 0.25 metres or less, he can see from this graph that such conditions will be exceeded 14 per cent of the time. Should a commercial deposit be identified, information of this sort can help in the selection of an appropriate dredging system.

Insofar as this wave recording station is in a relatively sheltered coastal embayment, it should not be considered representative of those conditions to be expected further offshore. It may, however, be a fair representation of wave conditions likely to occur in other embayments with a similar aspect.

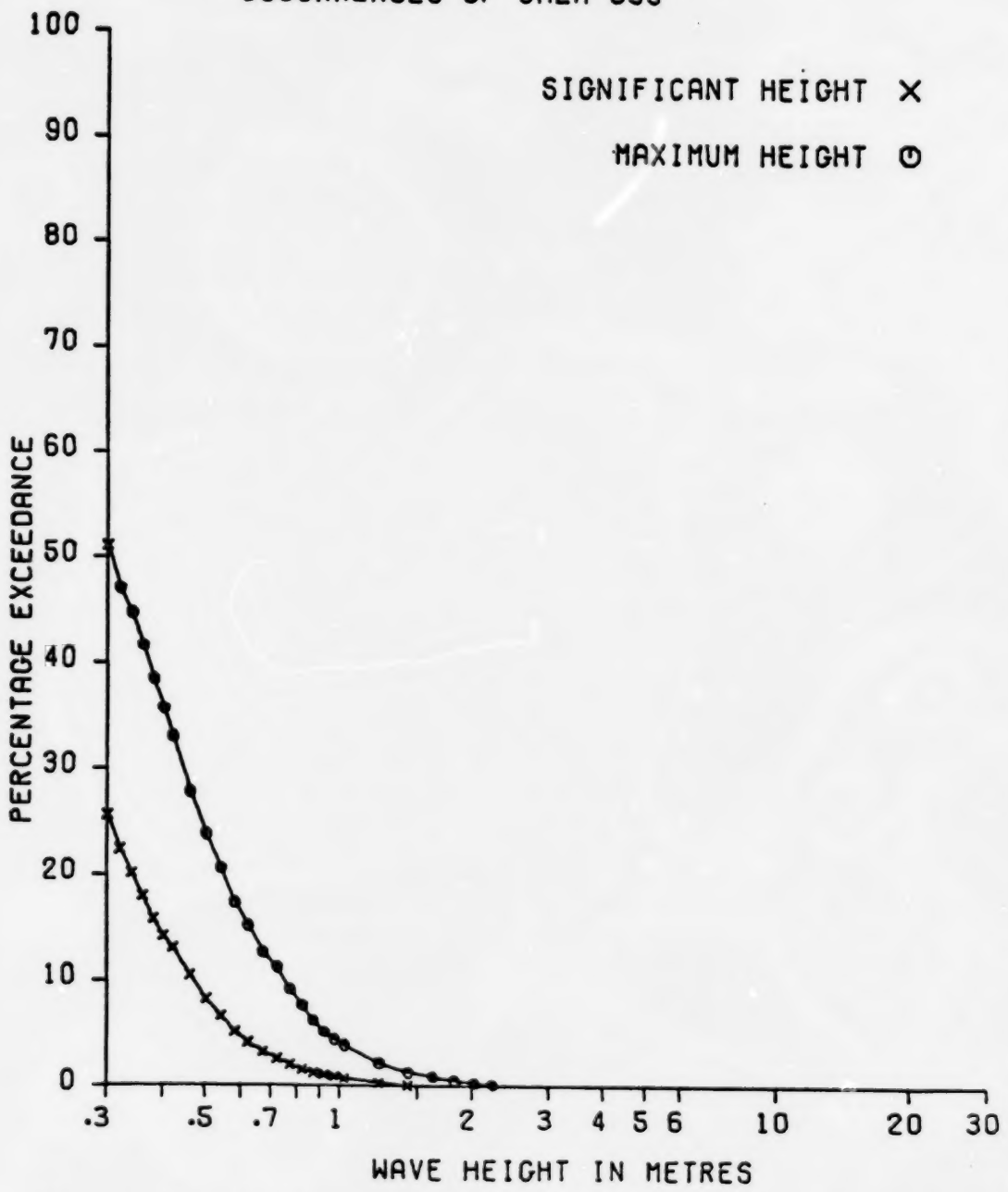


Figure 1. Graph illustrating the percent of time a specified wave height is expected to be exceeded.

Conceptual Mineral Deposit Models

Beach and marine placer gold deposits occur in a wide variety of settings worldwide and this cannot be attributed to a single formative mechanism. In tropical and sub-tropical regions, intense chemical weathering of bedrock produces a thick regolith which, given a suitable host rock, may contain gold and other placer minerals. In order to produce a coastal or offshore placer, the overburden must be situated along a conduit to the coast. This conduit usually takes the form of a high-gradient watershed. Upon reaching the coast there must be some means of accumulating and concentrating the heaving mineral fraction if an economic placer deposit is to accrue. If this concentrating mechanism is ongoing, the deposit can be termed a "contemporary" placer. If it was previously active, then the deposit is referred to as a "relict" deposit.

In mid-to-high latitude regions, mechanical weathering is generally the dominant process responsible for liberation of the heavy minerals from the bedrock. While glacial deposits do not usually contain commercial quantities of gold, they illustrate that glaciation can mobilize, transport and deposit high quantitites of material. Glacial transport can be several tens of kilometres, hence it is possible, given subsequent reworking by aeolian, fluvial or marine processes to yield and economic deposit remote from the source rock.

Within the Canadian Department of Energy, Mines and Resources is a Coordinating Committee on Ocean Mining. Members of this group have been investigating various aspects of nonfuel mineral resources for the past

decade. Two years ago, a project was undertaken to apply a previously developed assessment methodology to the Canadian offshore for unconsolidated, granular resources (Hale and McLaren, 1984). The study identified a number of problems pertaining to the assessment of resource potential. It found that, in many cases, there was no relevant information for the shallow coastal zone. Even where data were available, there was little in the way of applicable mineral deposit models upon which to base an appraisal of placer potential. There is, therefore, an ongoing project within the Ocean Mining Division, COGLA, to develop appropriate conceptual deposit models for offshore Nova Scotia.

The principal objective of study is to define and characterize, from an economic standpoint, the placer gold deposit sub-types. Where possible, attempts are being made to describe the typical tonnage and grade of each sub-type and to provide indications of their potential economic significance. The intent is to follow up this work with a field evaluation. The findings will be used to: provide better estimates of Canadian offshore placer gold resource potential and where the deposits may occur; identify favourable localities for further investigation and, assist in the evaluation of particular prospects. They are also intended to serve as a tool to assist industry make exploration decisions.

The preliminary findings indicate that gold may be present in five or more distinct placer sub-types. The gold can occur in the following types of deposits: glaciofluvial, glaciomarine, beach and isolated detrital lag concentrations. In many cases the occurrences cannot be

attributed to any single process, but rather a succession of events. Further details concerning this will be outlined at the various stop-points during the excursion.

During the field trip, you will become familiar with the aggregate market and availability in and about the Halifax-Lunenburg region. The offshore availability, possible environmental concerns associated with marine mining, the operating environment, and other factors that come into play in determining the viability of a marine aggregate industry will be discussed.

An area called the "Ovens" near Lunenburg, which has a gold mining history dating back to 1861, will be visited. Much of the gold was recovered from the beaches using gold pans and rockers. Although the level of activity tapered off by the end of the century, individuals continue to try their luck to this day.

At the "Ovens", the regional bedrock geology, glacial and sea level history and subsequent marine processes will be reviewed. This will enable us to discuss the distribution and types of placer deposits that may exist in the offshore.

If time permits, a visit may be made to an offshore exploration program currently being conducted in the region.

AGGREGATE INDUSTRY

PRODUCTION STOPS

John Fowler

These sites were selected to show opposite ends of the aggregate production spectrum in Nova Scotia.

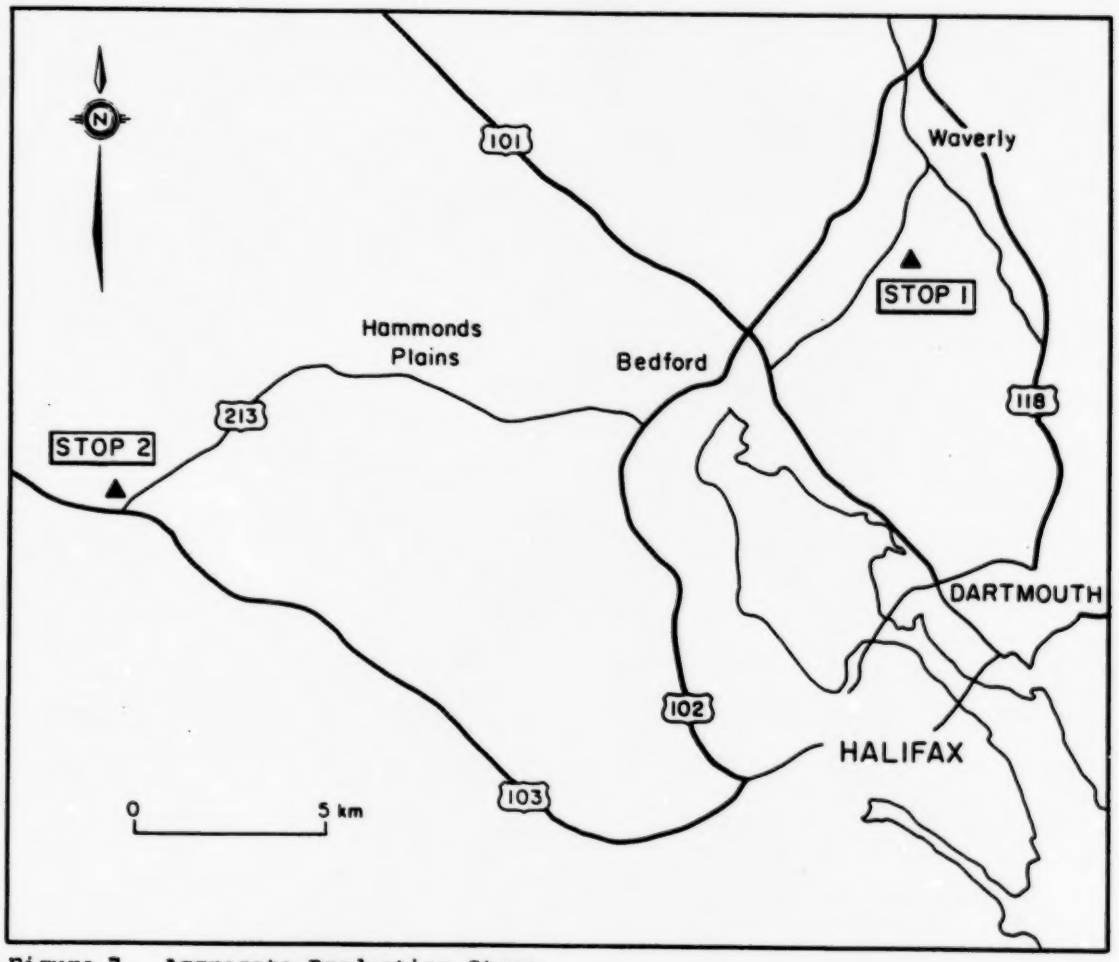


Figure 2. Aggregate Production Stops.

STOP 1 Rocky Lake Quarry at Rocky Lake, Halifax County is a idiary of Municipal Contracting Limited, and the largest aggregate pro- r in Nova Scotia. It is one of five aggregate quarries operating in metro area and like the other four producers, Rocky Lake mines the ro-Ordovician Meguma Group Goldenville Formation quartzite to produce ral grades of aggregate products mainly for local markets.

Crushing at the present time is being carried out in the area of arge anticline with estimated reserves at two hundred million 000 000) tonnes.

Aggregate produced supply local portland cement concrete pro- rs, local general contractors, and for the production of hot mix altic concrete at Municipal Contracting's plant which is located in the ry. Average annual production at this quarry site exceeds one million 00 000) tonnes.

Rocky Lake Quarry produces excellent quality materials which meet specifications set by the Provincial Department of Transportation, es of Halifax and Dartmouth and private agencies.

ROCKY LAKE QUARRY

a) **Major Equipment Used in This Quarrying Operation**

Drill-Drillmaster 6 1/2 inch hole	Ingersoll-Rand
Truck, haul, 35 ton capacity	Caterpillar Tractor Company
Crusher, primary 42 in. x 60 in Gyratory	Allis-Chalmers Corp.
Crusher, secondary 5 1/2 ft. shorthead x 2	Nordberg-Rexnord
tertiary, 4 1/2 ft. standard x 2	Nordberg-Rexnord
Feeders, vibrating x 3	Syntron
Screens, secondary, tertiary 5 x 20 DD x 8	HRE Industries
Front End Loader - Model 988	Caterpillar Tractor Company
Shovel - Cat 245	Caterpillar Tractor Company
Yard Loader, Model 980	Caterpillar Tractor Company
Conveyor Belting	Goodyear Tire and Rubber Company
Radial Stacker	HRE Industries

b) **Physical properties of the aggregate.**

Compressive Strength (PSI)	
1) Perpendicular to bedding	19100-23900
2) Parallel to bedding	10600-13400
Seismic Wave Velocity (ft/sec.)	15800-18000
Youngs Modulus (estimated) PSI	500,000
Poisson's Ratio (estimated)	0.25
Hardness (Moh's Scale)	7
Soundness (Na_2So_4) Loss-5 cycles	1%
Los Angeles Abrasion (500 revs)	15%
Specific Gravity	2.72 g/cc (169.7 pcf)
Bulk Density	1422 kg/m^3 (91 pcf)
Petrographic Number	105-110

c) **Chemical properties of the aggregate**

Loss of Ignition	2.81%	
Silica	85.52%	
Calcium (as CaO)	1.39%	
Magnesium (as Mg)	0.06%	
Sodium (as Na_2)	1.41%	
R_2O_3	9.55%	
Aluminum (as Al_2O_3)		3.93%
Iron (as Fe_2O_3)		5.31%
Manganese (as MnO_2)		0.11%
		9.35%
Copper	Trace	
Chromium	Trace	
Nickel	NIL	
Zinc	NIL	

STOP 2 Intersection of Highway 213 and Highway 103.

At the other end of the production spectrum tills are sometimes used as an aggregate source. At this site a loose, sandy granite till is screened and crushed to obtain a roadbuilding aggregate. These deposits can occur as a thin veneer or develop into thick hummocky deposits. Tills are generally considered a minor aggregate resource in Nova Scotia however, granite till and some other tills with a sandy matrix and durable clasts supply most of the aggegate used in some regions. These regions are small market areas where there are no sand and gravel deposits and the market does not justify quarry development.

THE OVENS

Craig Miller

INTRODUCTION

The "Ovens" are located on a peninsula approximately 12 miles (19.3 km) southeast of the town of Lunenburg (Fig. 3).

The name is derived from caverns in a rocky cliff of the shoreline of Lunenburg Bay. There is a legend that an Indian who entered the largest oven in his canoe made his exit at Annapolis Royal.

Most agree that the caverns were formed from natural processes of erosion by the pounding sea, but Heatherington (1874) said that the regularity at which these openings occur tends to disprove their being created merely by the action of waves. He contended that they were the result of human efforts, probably mining.

In 1935, the Ovens were turned into a privately-owned natural park and campground by relatives of James Meisner, a prominent figure in the first gold rush in 1861. Gradually, the park has improved and expanded its facilities, and has become a popular destination for campers. On the

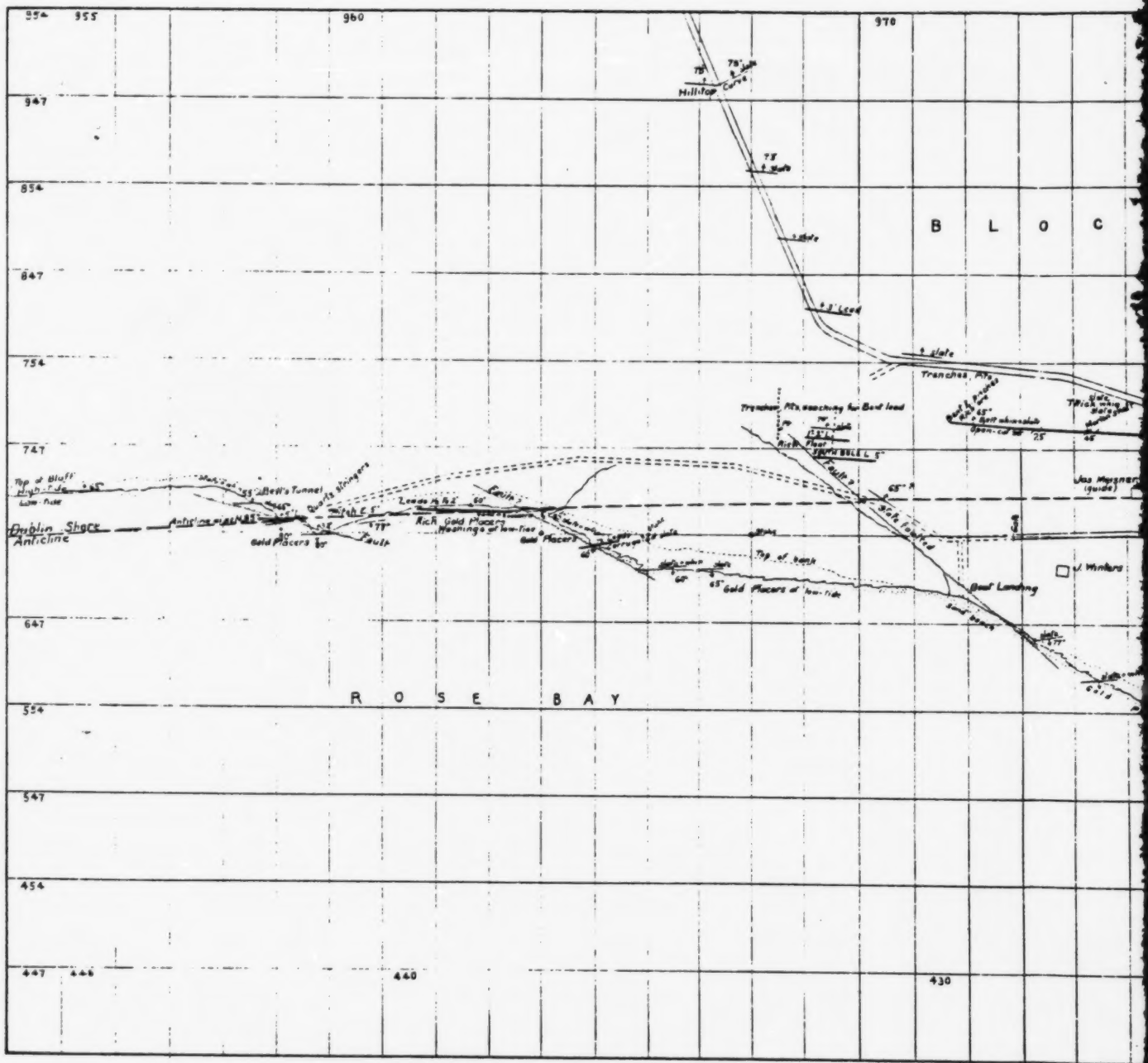
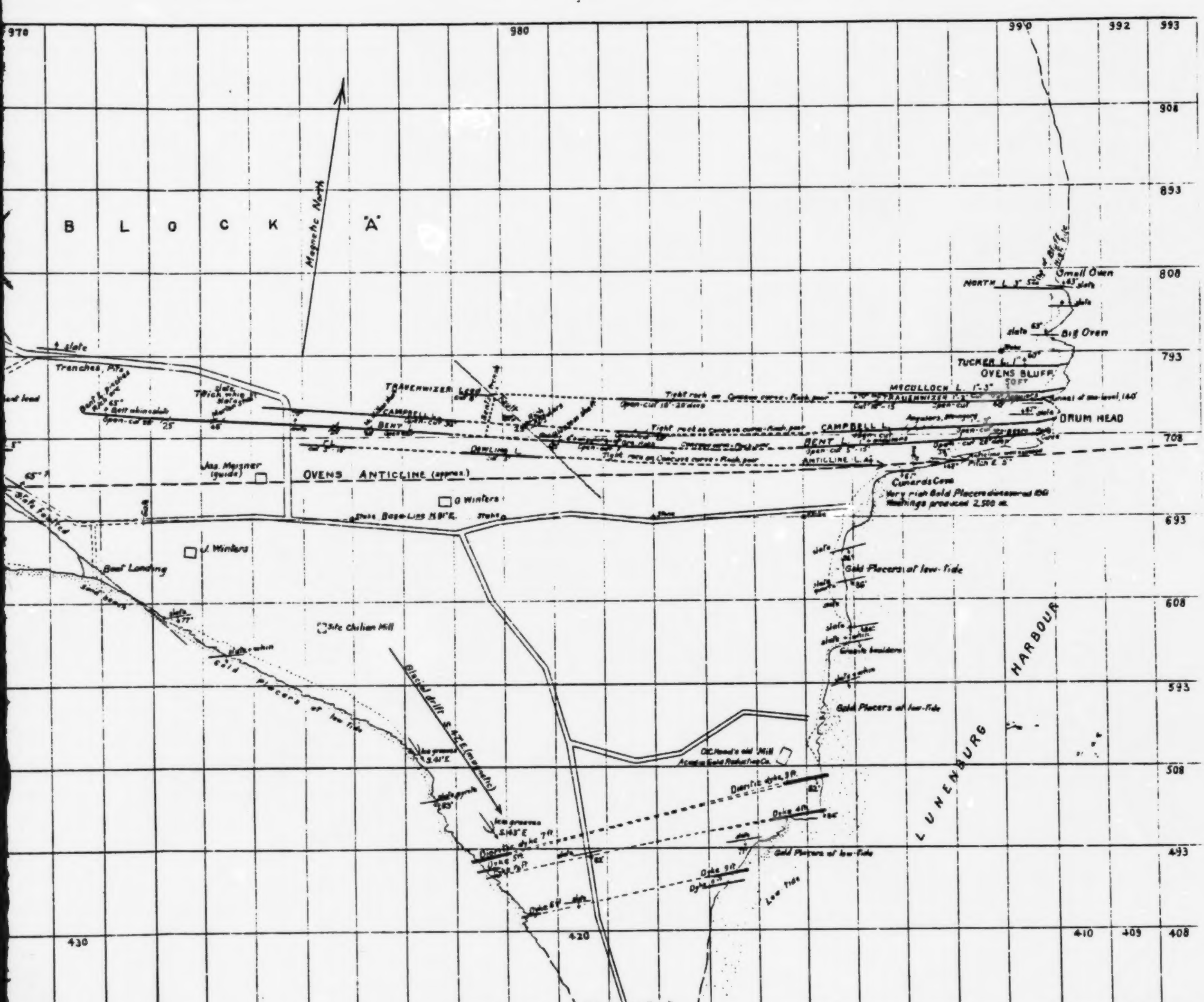


Figure 3. Location map and regional geology of the Ovens region (after Faribault, 1929).



BLOCK "A"
Magnetic North
Trenches, Pits
TRAVENWIZER Lead
CAMPBELL L.
BENT
Open-cut 38° 25
DOWLING L.
Jas. Meisner (guide)
OVENS ANTICLINE (approx.)
G Winters
Stake Base-Line N.81°E.
J. Winters
Boat Landing
Sand beach
Site Chilian Mill
Gold Placers at low tide
Glacial drift S.42°E.(magnetic)
Ice grooves S.41°E
Ice grooves S.45°E
Dioritic dyke 7ft
Dyke 5ft
Dyke 6ft
Fish-House Point
Small Oven
NORTH L.
Big Oven
TUCKER L.
OVENS BLUFF
McCULLOCH L. 1"-3"
Tunnel at sea-level 140'
DRUM HEAD
CAMPBELL L.
BENT L.
ANTICLINE L.
Pitch E 5°
Cunards Cove
Very rich Gold Placers discovered 1861
Washings produced 2,500 oz.
Gold Placers at low-tide
Granite boulders
Gold Placers at low-tide
O.C. Hood's old Mill
Acadia Gold Reducing Co.
Dioritic dyke 3ft
Dyke 4ft
Gold Placers at low-tide
Dyke 9ft
Low tide
LUNENBURG HARBOUR
970
980
990
992
993
908
893
808
793
708
693
608
593
508
493
408
409
410
420
430

OVENS GOLD DISTRICT
LUNENBURG CO., N.S.
Scale: 250 ft. to one Inch
E. R. Faribault
Geological Survey. Aug. 2nd 1909
Field Note-book 382 pages 58-71, 37
Guide. James Meisner

Compilation and Tracing by E. R. Faribault. March 4th. 1934

site there is a private museum which contains artifacts from the gold-mining days. Also on the site are two Chilean mills used to crush the auriferous quartz.

MINING HISTORY

The discovery of gold has been attributed to James Dowling, who, on June 13, 1861, located a three-quarter inch thick vein on a promontory called the Bluff under which the Ovens have formed. Friends of Herbert Tanner contended that Tanner had made a discovery earlier than Dowling. Prominent geologists of the day, John Campbell and Professor Silliman, said that they had panned gold from the beach sands of the shore in 1857 and 1859.

After Dowling's discovery, efforts concentrated on exploring for and exploiting the narrow lode deposits. Later in the summer, a government surveyor, John Lawson, discovered gold in the beach sands at Cunards Cove. Claims covering the beach sands became much in demand. Considerable confusion ensued along with a number of disputes, and a delegation of government officials, including the Provincial Secretary, Joseph Howe, set out by ship to visit the Ovens and restore order. Lots of 33 x 30 feet were laid out in the placer areas and sold for twenty dollars, the price of one ounce of gold.

A "mini gold rush" followed, with a number of prominent Halifax businessmen taking up claims. Claims were purchased in Halifax, which gave residents of the city an advantage in staking. Many a miner would make the long trek to Halifax only to find that the claim he wanted was already held by a speculator from the city.

Cunard Cove is named after one of the businessmen, William Cunard, son of Sir Samuel Cunard of steamship fame. Cunard and his partners, which included the geologist John Campbell, took out a considerable amount of gold from their claims before selling them for $6000. Some individual 33 x 30 feet lots were sold for as much as $5000.

By late 1861, the placer deposit was petering out, but some good returns were made in 1862. It has been estimated that about 2311 oz. (71 640 g) were produced to the end of 1862 (Heatherington, 1868).

After the economic placer gold was exhausted, the Ovens never again became a major contributor to the gold production of the Province. The gold rush lasted only a few years, during which time a small city had grown, complete with hotels, a school, churches and bars. Hopeful miners arrived from as far away as the goldfields of California. By 1868, the town was almost empty. Reasons for the rapid decline were attributed to the scarcity of easily acquired gold, and inefficiencies from the small mining lots and improper equipment. More money was spent on erecting the town than on mining and development.

New hope surfaced again in 1868 when four or five nuggets, one of which weighed 0.42 oz (13 g), were recovered from washing glacial till from the bottom of a 15-foot deep pit. The richest till occurred close to bedrock (Henry How, 1868).

Emphasis shifted back to the lode gold deposits, but nothing of consequence ever resulted. In 1869, efforts by prospectors were successful

in discovering some large and rich boulders on surface, which, when traced back to their source, revealed 10-12 lodes ranging in size up to five feet (1.5 m) thick. Some of these veins had good shows of gold (Messervey, 1929). However, by 1870, mining was again entirely dormant. Other tests done in 1869 on surficial materials indicated that several acres of till might be processed and crushed at a profit.

Local farmers continued to pan gold at the Ovens into the 20th century and sold their gold to jewellers in Bridgewater and Lunenburg.

Prospecting was carried out over the years and in 1896-97 some renewed interest was aroused. In 1896, five ounces (155 g) of gold were recovered from 26 tons (23.5 tonnes) of crushed ore. In 1897, 78 oz. (2428 g) of gold were recovered from 210 tons (190 tonnes) of ore crushed. Activity was once again short-lived.

In 1969, as part of an evaluation of offshore Nova Scotia for placer gold, Matachewan Canadian Gold Limited conducted seismic acoustic profiling and bottom sediment sampling off the Ovens in Cunard Cove and Rose Bay. In these two locations, they outlined six million cubic yards (4.6 million cubic metres) of material that contained gold ranging in value from a few cents to four dollars per cubic yard of sediment.

In 1980, A. M. Barrett conducted some mapping and sampling surveys along the north shore of Rose Bay.

EXPLORATION AND DEVELOPMENT

The Bent lead has been worked more than the other lodes, altogether over a strike length of 3000 feet, chiefly by open cuts and shallow shafts (the deepest shaft is 65 feet). The Campbell, Trauenwizer and Dowling leads were also worked by shallow open cuts. On the Trauenwizer lead, a tunnel was driven from sea level along the vein for 140 feet (42.7 m). This excavation is part of the park exhibits (Tuckers tunnel), with stairs leading down into the adit.

Offshore, Matachewan Canadian Gold Limited had completed, in 1968 and 1969, 123 nautical miles of seismic sub-bottom profiling in Lunenburg and Rose Bays, as well as 120 bottom samples taken with a jet lift hydraulic system. This work was done by Ocean Science and Engineering Incorporated. About 50 samples were taken around the Ovens Peninsula. Divers did some reconnaissance mapping of the bottom sediments and a marine magnetic survey was done by the Nova Scotia Research Foundation. The magnetic survey was done to determine if heavy magnetic minerals such as magnetite or pyrrhotite could be used as markers for gold. A major magnetic anomaly was delineated that coincided with the anticlinal axis, indicating a bedrock provenance for the anomaly. Matachewan outlined six million cubic yards of material in two favorable areas, but the erratic gold values prevented them from assigning a grade to it.

A suction dredge was constructed at Mahone Bay in 1969 and was intended to test the two favorable areas outlined in 1968 east of Ovens

Point and in Rose Bay. Much to Matachewan's surprise and disappointment, the six million cubic yards had disappeared over the intervening winter, probably due to the effects of storms. No further work was done.

GEOLOGY

Onshore

The rocks consist predominantly of slates with minor meta-graywacke of the Halifax Formation, Meguma Group. The beds have been tightly folded into an anticline that can be seen in Cunard Cove and farther west along Rose Bay. The anticline plunges east at an angle of five degrees. Strata of the north limb dip 60-70 degrees while those on the south limb dip between 80-85 degrees. South of the anticlinal axis occur several diorite dykes that trend nearly parallel to the strata. These dykes are five to nine feet (1.5-2.7 m) thick and have no apparent connection with the gold mineralization. At low tide, beds containing appreciable pyrite can be observed in Cunard Cove. The geology of the district is shown in Figure 4 (in pocket). The regional geology is shown in Figure 3.

The auriferous quartz veins are parallel to the bedding in the slates. A number of crosscutting veins intersect the bedded-type veins at right angles, and where such veins entered the Bent Lode, made it auriferous at the point of intersection. The crosscutting veins have been faulted off by movements along the bedding planes during folding.

In addition to gold, scheelite has been found in a vein located in the northeast corner of Claim M, Tract 49. Appreciable scheelite can be panned from a gray clay resting on the slate till at the till/bedrock interface in Cunard Cove.

A concentrate of pyrite derived from crushing quartz is reported to have given 242 oz./ton (8228 g/tonne) gold and 16 oz./ton (544 g/tonne) silver.

Overlying the slate and graywacke bedrock at Cunard Cove is a dark grey till consisting predominately of locally derived slate, graywacke and quartz, and lesser amounts of more distal granite clasts in a clay-silt matrix. Locally, this till ranges in thickness from less than one metre to ten metres.

The natural grinding-mill action of glacial ice as it passed over bedrock hosting auriferous quartz veins served to liberate gold and other minerals, including scheelite, from the rock, leaving behind a mineralized till deposit. At Cunard Cove, sea cliff erosion and beach wave action working on the till are concentrated the heavy minerals in sand and gravel pockets on the beach. The effects of these processes will be seen at STOP 3 (Fig. 5).

On the south side of the Ovens Peninsula, west of Ovens Reef, is an interesting till section consisting of two tills where the more extensive brown-gray, locally-derived slate till is overlain by a red brown till (STOP 4, Fig. 5).

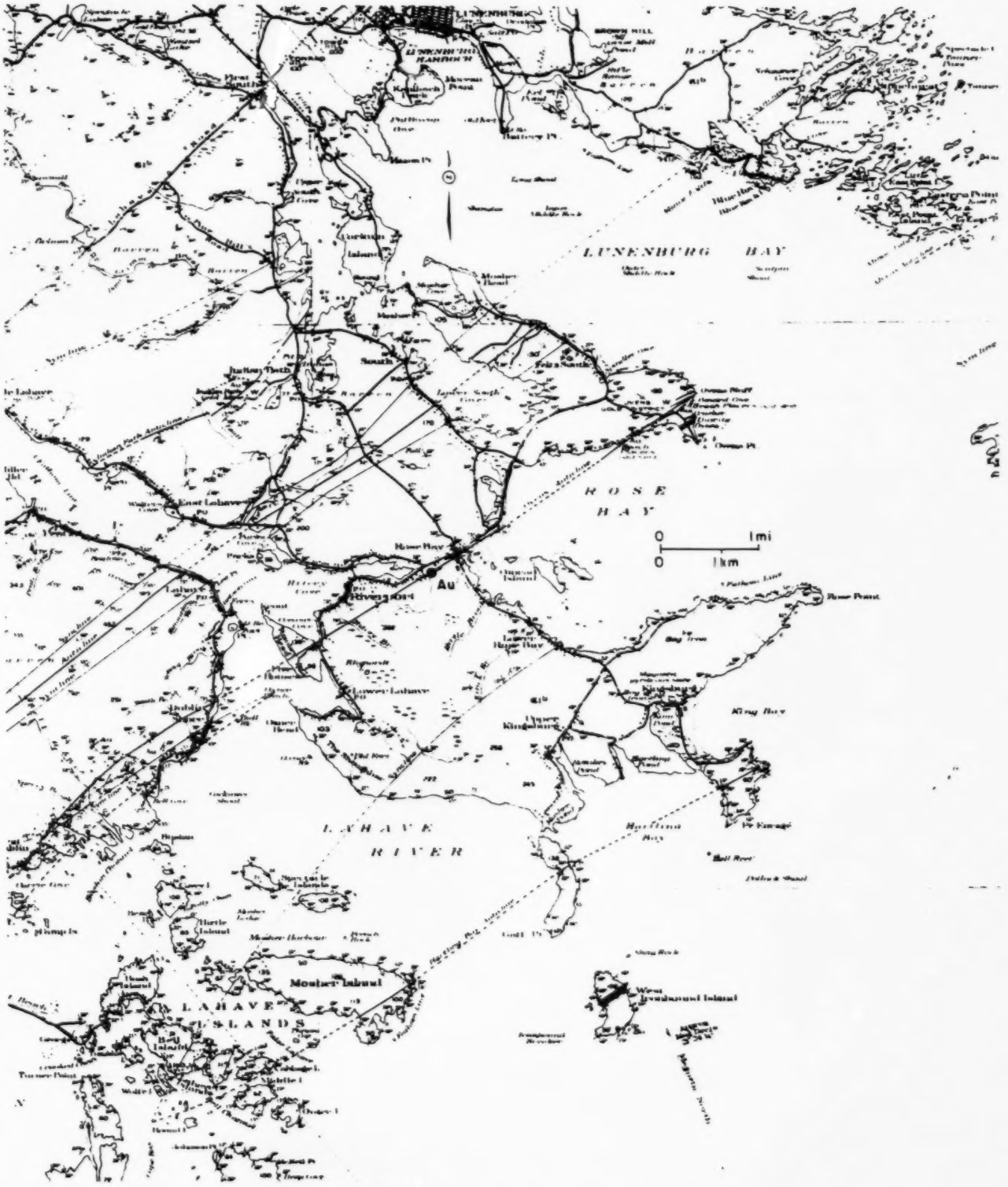


Figure 4. Geology map of the Ovens (after Faribault, 1934).

The lower till is approximately eight metres in thickness and consists of slate, graywacke and granite clasts in a silty matrix. The upper till contains many locally derived clasts but is easily identifiable as a far travelled till because of its colour and by some of the pebbles and boulders within the till.

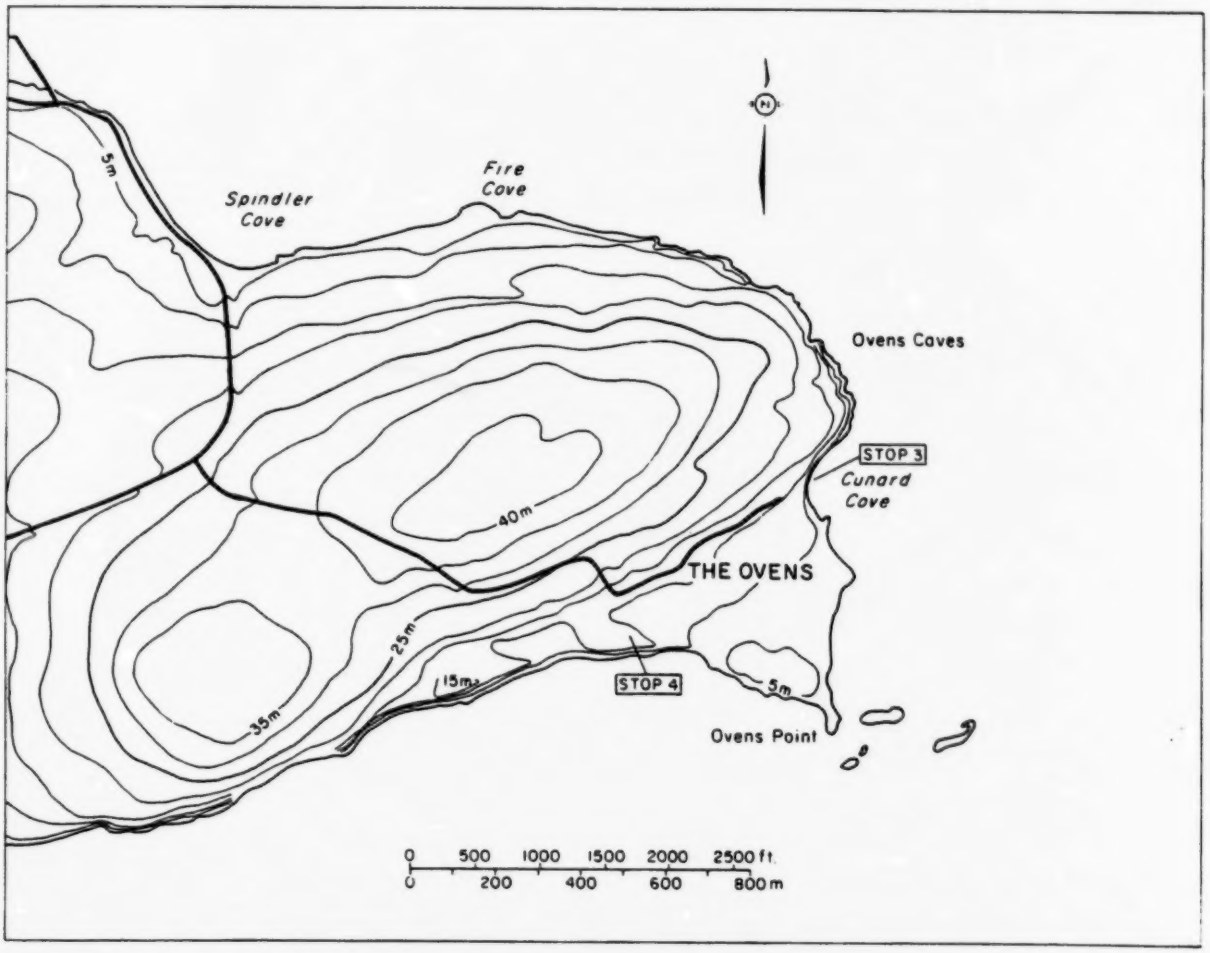


Figure 5. Location map showing the field trip stops.

The red brown colour is attributed to silt and clay derived from sediments in the Bay of Fundy or from Triassic red bed formations in the Annapolis Valley Region. The amygdaloidal basalt pebbles and boulders, also found in the upper till, came from the North Mountain Basalt outcropping along the Fundy Shore. These deposits are located 90 km up ice from the Ovens.

The upper till, referred to as the Lawrencetown till, is widely distributed in Lunenburg County, forming numerous drumlins on land and small drumlin islands in Lunenburg and Mahone Bays. In contrast to the locally derived slate quartzite and granite tills, soils developed on Lawrencetown till are fertile and used extensively for farming.

Offshore

The continuation of the anticline can be traced out to sea in several places, especially from the Ovens peninsula eastward 3 miles (4.82 km) across Lunenburg Bay to East Point Island (Fig. 3). Since both the Ovens peninsula and East Point Island have known in situ quartz veins at the water's edge, the anticlinal zone under the bay may have placer gold potential. The same anticline can be followed westward for 2.5 miles (4.0 km) across Rose Bay to Riverport where a gold occurrence is reported (Fig. 3).

The coastline is characterized by moderate-to-low undulating topography terminating in abrupt cliffs at the water's edge, with rocky headlands and long, fairly wide sandy beaches in the embayments.

Lunenburg Bay is considered to be a major drowned drainage channel, as interpreted from bathymetric and seismic data. The seismic profiles indicate considerable thicknesses of alluvial material in the channels. Bottom materials for most of Lunenburg Bay range in size from well sorted fine-grained sands to clean boulders; a clay and silt bottom

cover is lacking. About 50 samples were taken in the area of the Ovens peninsula by Matachawan, and nearly all samples had some gold in them.

The beach sands at Cunard Cove contain arsenopyrite and pyrite, some magnetite, scheelite and gold (McLeod, 1959).

In the Rose Bay area, coarse-to medium-grained sand predominates with abundant ripple marks indicating active transport. Seaward of the sand are extensive deposits of relatively unsorted material. Landward of the sand occurs a narrow strip of gravel and then bedrock to the shore.

East and southeast of the Ovens peninsula, the unconsolidated material is bouldery close to the contact with bedrock, but boulders and cobbles become scarce seaward. The unconsolidated materials fan out from the Ovens Point isthmus seaward and widen rapidly. Established plants and animal habitats indicate little active sediment transport close to the shore but in deeper water beyond 30 feet (9 m), numerous three-foot (1 m) wavelength ripples were observed by Matachewan divers. The bottom of the Ovens is mostly bedrock to a water depth of about 50 feet (15 m).

ECONOMIC CONSIDERATIONS

With about 2500 oz. of gold produced from the limited beach placer deposit in Cunard Cove, is it reasonable to expect significant concentrations of gold offshore?

From the geology map of the Ovens (Fig. 4), the main zone of veins occurs on the north limb of the fold just north and west of Cunard Cove. These veins occur within an area 3000 feet long by 500 feet wide (914 x 152 m). Within this area, the aggregate thickness of interbedded auriferous quartz veins is only about 11 inches (0.28 m), or about 0.18 per cent by volume. However, gold can occur in sulphide rich zones within the sediments themselves, as well as in the numerous crosscutting veins outcropping on the shore. The writer estimates about one percent of the entire volume is auriferous and the grade of the auriferous material is .50 oz./ton (17 g/tonne).

An area of 3000 x 500 feet would contain 125,000 tons (113 375 tonnes) of material, of which 1,250 tons (1134 tonnes) would be auriferous. In total, 625 ounces of gold would be available from this area per foot (63 700 g per metre) of depth.

The average till cover for the area is 15 feet (4.6 m). This means that within the 3000 x 500 foot area, there exists 835,000 cu. yds. (638 775 cubic metres) of material (1,460,000 tons or 1 324 220 tonnes) which tonnage represents 11 feet (3.4 m) of erosion for the area. Comminution of 11.0 feet would release 6875 ounces (213 125 g) of gold.

Given the geometry of Cunard Cove, the distribution of the veins and the direction of glaciation, the gold in Cunards Cove was probably contributed to from a smaller area 1200 feet long by 500 feet wide (360 x 152 m). Such an area would contain 50,000 tons of rock per foot (148 748 tonnes per metre) of erosion, of which 500 tons would be auriferous.

Therefore, there would be 250 oz. of gold available per foot (25 420 g per metre) of erosion, and for 11 feet (3.35 m) of erosion, this would amount to 2750 ounces of gold (85 228 g).

With the above assumptions, the gold recovered from Cunard Cove can be explained solely by the erosion of the local auriferous glacial tills which reflect the underlying bedrock. However, some gold has probably been derived directly from erosion of the bedrock, but the amount is not considered to be significant.

Since the richest placers occurred in Cunard Cove and on Rose Bay where the anticline intersects the shoreline (the zone of maximum veining), it is apparent the exposed auriferous tills have not been displaced very far down ice.

The economic potential of offshore Ovens will be entirely dependent upon the existence of auriferous veins in volume under Lunenburg and Rose Bays. No information exists on this subject.

CONCLUSIONS

The beach placer deposits in Cunards Cove and Rose Bay were in all probability formed from the erosion of auriferous tills derived from the comminution by glaciers of the underlying bedrock. These tills were eroded over the bank onto the beach areas. The waves sorted this material and concentrated gold between the high and low tide marks in crevices and other depressions in the bedrock surface. The finer-grained gold was probably winnowed with the silt, clay and fine-grained sand.

Given the small volume of auriferous bedrock and thin till deposits derived from it, the size of placer concentrations off the Ovens will not be great.

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